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THE GREAT PLAINS.*

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Fifty years ago the cartographers were not quite done imprinting upon the maps of North America, in letters reaching from the Rocky Mountains nearly to the Missouri River, the legend "Great American Desert." Steadily the boundaries of this mythical Sahara shrank away until only an oval figure was left, with letters small, covering a part of what is now western Kansas and Nebraska and eastern Colorado. Vague stories told by the early explorers of a vast waterless area, wind-swept and bare under the summer's sun, were easily enough magnified in popular literature into tales of desolation and death. But they were far from the truth of those semi-arid plains, often parched and burnt through the long summer months, but clad for much of the year in a carpet-like verdure of the softest green, ablaze with flowers and swarming with life. In the midst of what was once supposed to be the Great American Desert I have known forty bushels of wheat grown on a single acre and without irrigation.

But there are many interesting things concerning this large and indefinite area, the Great Plains, that have never ben told—physiographical, meteorological, geological and biological. Perhaps the knowledge gained in many years' exploration upon them may enable me to gather up some of these things for your present edification.

The first white man to traverse any part of the Great Plains was Cabeca de Vaca, who, in 1535, reached as far north as southern Colorado and southwestern Kansas. His was the first description of the bison, those characteristic animals of the plains. "Cattel come as far as this. I have seen them three times and

*Read before the Geographical Society of Chicago.

eaten of their meat. I think that they are about the size of those of Spain. They have small horns like the cows of Morocco, and the hair is very long and flocky, like that of the merino; some are light brown, others black."

The renowned and cruel DeSoto is reputed to have advanced far in the southern plains a few years later. His historian describes great chains of mountains to the west, which become visible for the first time beyond the boundaries of Kansas. It was Coronado, however, to whom fame has usually ascribed the honor of first crossing any part of the Great Plains, in 1541. The line of march of this famous expedition has, within a few years been well traced from the starting point in New Mexico, along the Arkansas River and down the valley of the Smoky Hill to the beginning of the Kaw, a hundred and twenty miles due west from the present site of Kansas City. Coronado did not find the rich kingdom strewn with gold which he so eagerly sought, his mythical Quivera, but he did enter the borders of one of the most fertile regions of all America. In the words of his historian, "From Cicuye they went to Quivera, which after their account is almost three hundred leagues distant, through mighty plains and sandy heaths, so smooth and wearisome and bare of wood that they made heaps of ox-dung for want of stones and trees, that they might not lose themselves at their return; for three horses were lost on that plain, and one Spaniard which went from his company on hunting. All that way of plains are as full of crooked back oxen as the mountain Sierra in Spain is full of sheep, but there is no such people as keep those cattle. These oxen are of the bigness and the color of our bulls, but their bones are not so great. They have a great bunch upon the fore shoulders and more hair upon their fore part than on their hinder part, and it is like wool. It is a foul and fierce beast of countenance and form of body. The horses fled from them because of their deformed shape. The number was incredible."

The historian quaintly adds an incident that is yet not very rare upon those plains. "One day it rained in that plain a great shower of hail as big as oranges, which caused many tears, weakness and vowes."

For more than one hundred years we have no other record of the visitation of white men to any part of the Great Plains. About 1650 a disaffected party of the Pueblo Indians, fleeing from the oppression of the Spaniards in New Mexico, went far out into the midst of the plains and settled in a small but fertile valley near

the western part of Kansas, and there built a village, which the Spaniards called Cuartelejo, a settlement which, seventy-five years later, became of some importance. The site of this village, long unknown, it was my good fortune to identify a few years ago. In the latter part of the seventeenth century several expeditions were sent thither by the Spaniards in the unavailing attempt to bring the disaffected again into subjection, and after the beginning of the eighteenth century it became, it is said, a rendezvous for both the Spaniards and the French. We found at the site only the remains of a conflagration and tools of white men's and Indians' make. The village was situated near the Smoky Hill River, about sixty miles east of the Colorado line.

About twenty years ago a steel shirt of mail was dug from a mound near McPherson in the central part of Kansas by Professor Udden. A few years ago an old Spanish sword, with characteristic inscriptions was exhumed far out on the plains, not far from the Colorado line. That both mailed shirt and sword date back nigh or fully two hundred years is as certain as well may be. This old weapon, worn perhaps by some Spanish knight two centuries or more ago, awoke in me reflections as I examined it shortly after its discovery near the olden village of Cuartelejo in that olden province of San Luis. It bore the favorite Castilian inscription "No me saquer sin razon, no me embainer sin honor." The name it bore was that of one of Coronado's officers, so well as it could be deciphered—perhaps it was he who lost it with his life; perhaps some other of like name long afterward, but, though never beaten into a pruning hook, it was ploughed from a wheatfield in the peaceful vocation of husbandry.

The Great Plains comprise a vast area, from three to five hundred miles in width, extending from the llana estacada of Texas into British Columbia, east of the Rocky Mountains, characterized throughout by the absence of forests and the prevalence of aridity. In a more restricted sense, and as more popularly known, it is that area south of the Back Hills in Nebraska, Kansas, Colorado, the Indian Territory and northwestern Texas, and it is of this region especially that I shall speak. The altitude of eastern Kansas and eastern Nebraska, near the Missouri River, is about eight hundred feet; that of the plains near the foothills of the mountains more than five thousand feet. The more marked acclivity begins, however, near the 98th meridian or beyond the middle of Kansas and Nebraska, or about one hundred and fifty

miles east of the Colorado line, and it is here that rapid changes in the meteorological and biological conditions begin.

Underlying the whole of the region which I have outlined are soft limestone and chalk rocks of Cretaceous age, aggregating perhaps one thousand feet in thickness. The dip of these rocks is somewhat to the east, while that of the older rocks further east is toward the west or northwest. Some of the underlying rocks thin out much to the west, but others of younger Cretaceous age take their place. Overlying these Cretaceous deposits over the whole vast extent of these plains are from one to two hundred feet of a coarse, sandy marl belonging to late Miocene age. In the long interval between the close of the Cretaceous epochs to the beginning of the time of these Loup Fork beds whatever material had been accumulated by Tertiary freshwater lakes, if any, had been swept away over the southern plains. The coarse, sandy conglomerate, so intermixed with the worked over material of the subjacent chalky rocks resembles so perfectly old mortar, that the deposits are commonly known by that term, and it is, for the most part of fluviatile origin. It occurs over thousands of square miles of area, and contains almost everywhere, remains of river plains, animals, often in extraordinary quantities—rhinoceroses, mastodons, tortoises, and various carnivores. In many places I have found at or near the base of this Loup Fork material, and far below the base of the upland beds, in the old river beds, large siliceous boulders weighing as much as fifty pounds or more.

Ever since the latter part of the Miocene times, then, there have been no great lake deposits upon the plains, but for long ages there were many and torrential rivers flowing eastward over them.

From the close of this fluvial condition, that is from the time when great rainfalls and rushing streams ceased, there has been a constant upgrowth of the plains throughout the most of their extent, a constant deposition of fine dust blown in from the Rocky Mountains by the almost constant westerly winds. From one to two hundred feet in thickness, this aeolian marl forms a gently sloping blanket over the plains as far as the erosive powers of the less arid regions do not counterbalance the upbuilding processes. These flat upland plains between the broad and gently sloping drainage courses present a most remarkable uniformity. Some years ago I tested repeatedly with an excellent barometer the plains of the high divide south of the Smoky Hill River, near the line of Colorado. In a distance of twenty-three miles nearly north and south I found nowhere a variation of more than ten

feet from a level, and nowhere in this twenty-three miles did the road diverge more than a mile from a straight line. But the surface slopes distinctly toward the east, until it is finally broken up into the more rounded contours and deepened drainage courses of the less arid regions. The upbuilding forces of the arid plains are to-day greater upon the whole than the erosive ones. How long this condition has existed can not be said, but from the fact that there are more than one hundred feet of this upland aeolian marl covering the eastern part of the plains everywhere, it is very certain that the period has not been short. Characteristic Pleistocene fossils—horses, elephants, peccaries, camels, etc., are often found but a few feet below the surface, hence one may conclude that the rate of deposition in general is slow.

We may infer then, with good reason, that the physical conditions of the southern plains at least have not changed much since Miocene times, certainly for thousands of years they have been essentially as they are now, semi-arid, and clothed with buffalo grass. The chief rivers of the southern plains are the Platte on the north, taking origin in and near the mountains, the Arkansas on the south, also arising far in the Rocky Mountains, and the Smoky Hill, the headwaters of the Kaw River, between. Further to the south the headwaters of the Red River drain a part of the plains. And all these rivers are much alike. Like the Platte, each might make a respectable stream if "it were turned up edgewise." Through much of their course on the plains they are subterranean, flowing beneath the sands, often reappearing in long stretches at the coolness of nightfall to disappear under the ardent heat of the morning sun.

Near the Missouri River in Kansas and Nebraska the average rainfall is about forty inches annually. In the extreme western part of Kansas and Nebraska the average is from eight to twelve inches. The meteorological conditions are thus it is seen nearly uniform over most of this great area, save such as are due to latitude and elevation. As in all arid and semi-arid regions the rainfall is spasmodic, thunder and hail storms alternating with long periods of drouth. This semi-aridity has produced in some parts localized bad land topography, denuded areas weathered into precipitous canyons and benches. That the bad-land conditions are not more pronounced is due in part to the geological conditions, in part to the gentle declivity eastward, in part to the moderate rainfalls. Throughout the large part of these plains, from Dakota to Texas at least the summer temperature is excessive.

not as great as in the Arizona and New Mexico regions, but much greater than in any part of the Rocky Mountains or westward, the thermometer ranging from 96 to as high as 120 during most of July and August. The more uniform temperature often persistent for weeks together, is from 98 to 103.

Summer, that is, the period of high temperature, begins about June 20 and continues to the middle of September. Three years in four the buffalo grass is cured and sufficiently dry to burn by the end of the first week in July. In recent years conflagrations have been for the most part prevented by stringent laws, but as late as 1875 it was the almost invariable rule for prairie fires to begin their devastation early in July. Fires in those times were started for the most part by the Indians. During all this time the winds are almost incessantly from the west or southwest, and they are usually hot and dry, parching and burning. The Jumbo windmills of the plains, simply overshot water wheels, are always placed north and south, and there are few days when they are not in motion during the summer.

The lessened precipitation of water, the hot and dry winds, the absence of shade, the sudden and marked changes in temperature —I once knew the thermometer in a day in July to fall from 102 at noonday to 44 at sunset—all combine to exert a profound influence on the animal and plant life. Faunas and floras change with startling rapidity west of the 100th meridian; east of that they are prevailingly of the Atlantic type; west, of the Pacific. As we well know, it is not the mountains which serve as the great east and west barrier between faunas and floras, but the arid plains—that is the conditions of heat, moisture and extremes of temperature. The characteristic buffalo grass begins here to cover up both upland and lowland. Further east, for perhaps one hundred miles, this low-growing, fine-leafed and curly grass is occasionally seen in upland patches of sterile soil, but it struggles for existence only in the barren and driest places. Its tenacity of life is extraordinary; burnt apparently to a crisp, though rich still in nutrition, it lies during most summers apparently without life, to again take on new freshness and greenness with the autumn rains. It invades all places upon the plains, where there is not too much moisture. Plowed fields left fallow, as have been so many upon the plains in the late years, are first overgrown with the omnipresent sunflowers, stunted and small, to give place in a few years to the buffalo grass. Nothing conquers it save the sagebrush and greasewood. It is a common belief, that with the ad-

vent of man, the long stemmed grasses are taking its place, but I have known the plains for thirty years and I know no difference in its distribution.

The soil of the plains is of great richness everywhere, and needs only moisture to make it teem with life. In early spring, before the withering siroccos begin, the prairies everywhere are ablaze with flowers. Enotheras with their large yellow blossoms at nightfall; the bush morning-glory, the so-called soapweed of some, in its brilliant green through the whole summer, ablaze with large purple flowers. It is a curious plant, so dependent upon arid conditions that one transplanted to my garden in eastern Kansas refused to blossom and sulked through many years until the congenial climate of 1901, hot and arid, brought out all its pristine glory. The painted Gaillardias make the hillsides glow with their rich colors; while the large, creamy flowers of Menzelia, under the most barren conditions, bespangle acres of desert land at nightfall. The Mexican poppies, Argemone, often give a white sheen to favored places; and the gorgeous creamy flowers of the yucca, and the glowing red and yellow flowers of numerous cacti are everywhere.

Perhaps it may seem like an exaggeration, but nowhere I believe is the earth more redolent of many hued blossoms than are many parts of these same plains in spring and early summer. Whoever in the northern plains has seen in June the acres upon acres fairly glistening with the beautiful calichortus lilies, or blue with larkspurs and petalostemons, whitened by the showy leaves of the Euphorbia, like "snow upon the mountain," or reddened by the Gaillardias, might little suspect how arid and parched and dreary the land everywhere becomes later. They furnished the colors for many an imaginative picture of the early settlers, that later faded into monochrome. From the western part of Kansas the odoriferous and scraggy sagebrush becomes a predominant part of the landscape, with its hated rival the greasewood, to drive out utterly all other vegetation in that most barren region of all America, western Wyoming.

Bird-life in spring and autumn is but little less abundant and varied than in the most favored regions. During the long summer season, the cowbirds, the bobolinks and upland plover, the shorelarks and buntings, inhabit the whole region of the plains, Even the mockingbirds and the orioles find congenial homes among the sparse willows and cottonwoods of the streams. But, most characteristic of all, is the staring and solemn burrowing

owl. Perched upon his mound near the entrance of some old burrow—for while he lives in peace with the prairie dog, he prefers a greater privacy than these noisy creatures permit him—he gazes at you with wide open and impassive countenance. As you pass him by, his head, like that of a punchinello, turns to follow your movement until one wonders how it is attached to the rest of the body; if you come too near, after a few minuet-like courtesies, he utters a strident squawk like unto the filing of a saw and flies to some more remote mound to resume his pensive reveries. But he, too, is slowly going the way of the prairie dog and antelope, though he will always linger while the prairie dog can bark and scold.

In insect life the fauna of the plains, for the most part, is strikingly characteristic. Wingless, crawling and burrowing beetles are omnipresent, many of them of large size and provided with a remarkable means for their protection, the power of ejecting a stream of vile and nauseous fluid when disturbed. Burrowing hymenoptera of numerous kinds and incredible numbers abound everywhere. One form, whose habits I described years ago, and common everywhere, closes its entrance to the burrows where its young are hatched and their food is stored, by means of a small pebble, and then tamps off the surface and seals the entrance by means of another pebble held between its mandibles. Predaceous robber-flies, and the parasitic, sun-loving Bombylüdae flies, all of which rear their young in the ground, are characteristic two-winged insects.

Locusts are, of course, everywhere where they can find anything to devour, and most characteristic of them all is that wingless, overgrown, lubberly one which I used to know as *Brachypeplus,* that can never hop without turning a somersault, and so stupid that he will eat off his own legs with apparent relish if you are kind enough to put their ends in his mouth. In general, as might be supposed, there is a comparative absence of all those insects which breed in moist places or among dense vegetation. The lepidoptera in particular are very inconspicuous. The insect fauna is markedly of the western or Pacific type.

Of the reptiles there are a few very characteristic forms, the rattlesnake, the so-called racer, and the little swift lizards (*Sceleropus*). Snakes there are in plenty besides these, but these are omnipresent, the rattlesnakes less abundant than formerly, though still sufficiently numerous for all useful purposes, as I was convinced the last day I spent in camp lately on the plains, when one

was found entangled in my sleeping blankets. The western march of civilization and the cowboys have not been most conducive to their welfare. They spend a large part of the summer months ensconced in any hole that will give them shelter, usually the prairie dog holes, where they find both board and lodging. But the little marmots know them well; I have observed too many instances to doubt that these wise little creatures, when they can get rid of their enemies in no other ways, will sometimes immure them in their burrows to die of starvation.

The characteristic mammals of the plains are the prairie dogs, jackrabbits, coyotes, grey wolves, and in olden times the antelopes, bisons and wild horses. The grey wolf still lingers, but his pristine glory on the plains is nearly gone. He has for the most part left those haunts where he has reigned supreme among the dog family for thousands of years. I have found his fossil bones deep down in the plains marl associated with the remains of the elephants and peccaries. The sneaking, disreputable cowardly, and in general abominable, coyote has also slunk into comparative oblivion on the plains, though he is still there and will always be there so long as man and cattle are. The time when he and his ugly cousin and master lived in paradise was during the slaughter of the bisons thirty-five years ago. They then waxed fat and numerous beyond all description. I once spent a night, long years ago, lost and alone, far out on the plains, surrounded by a hungry pack of these cheerful imps and I have never forgotten them. If all the coyotes now in existence could be corralled on the top of Mount Pélé, and I could start off the old volcano just long enough to annihilate them it would give me glee.

Of the countless antelopes that once inhabited these plains, nearly all are gone. There was rarely a day thirty years ago, that scores could not be seen in a few miles' march. Most remarkably timid, and fearful of all unusual sights they were most easily tamed of all animals, and it is a strange thing to me that someone has not attempted their domestication. Disappearing they are, too, in the mountains. A few I saw last summer in the most bleak and barren region of all Wyoming, the continental divide—but they are rapidly going the way of the elk and the bison.

Of the bisons I have elsewhere spoken and the tale is too long to repeat. The great plains of northern Texas, Oklahoma, Kansas, Colorado and Nebraska were once their home above all other places. During the great slaughter of the five millions in Kansas I have seen their carcasses strewn over acres of ground so closely

that one could step from one to another. I have seen train load after train load of their pelts shipped east and sold for two dollars apiece. I believe that their succor has come too late—these crooked backed oxen are doomed to an absolute extinction within the present century.

For two or three centuries the Great Plains were the home of wild horses, descendants doubtless of the old Spanish stock, perhaps in fact of Coronado's, constantly replenished by mares led away from civilization. I have seen many herds of them but, within the last twenty years, they exist no longer in their old home. An insufferable nuisance to the border settler, they were captured or ruthlessly destroyed.

About twenty years ago a serious attempt was made to develop agriculture over the plains, but the experiment was, for the most part, a costly and painful one, not only to those who experimented, but also to those who "grub-staked" them. Most of the so-called farms of western Kansas and eastern Colorado have returned to their pristine buffalo grass, and the old sod-house has fallen in—there are many of them. The cattle men are re-invading the region, and there they will stay until some better means for irrigation are discovered than now seems probable. And the plains are slowly returning to their former condition, save for the barbarous fences, that keep the cattle in and the traveller out. The antelope is again appearing in some places, the mule deer is occasionally seen again, but the buffalo, wild horse and wild turkey are gone forever. Even that lop-sided caricature, the jackrabbit, is disappearing and leaving his old haunts, as in the mountains, to the invasion of the degenerate cotton-tail. Only that chattering automaton, the sleek and well-fed prairie dog, has thriven and multiplied in the land, multiplied until he is in fair way of taking possession of the earth. He has always been in evidence, comical creature that he is, but never so ubiquitously, impertinently so as at the present time. He scorns good season and bad season. All that he asks is the opportunity to chat with his near-by neighbor and scold at all intruders. He always reminds me of my boyhood toys, for every one of his vehement barks seems to jerk a string attached to his shabby little pump-handled tail. He prudently banks up his house entrance to keep the rains out, and he sets a good example in his neatly kept dooryard; he grows fat on buffalo grass and the farmer's wheat in summer, and finds surcease of trouble by sleeping all winter. They are trying now to educate in him a

liking for corn steeped in strychnine, but he does not take very kindly to the diet, improvident as he is, and I have a sort of sneaking hope that he never may.

I had well nigh forgotten to mention the most characteristic mammal of the Plains after all, the noble red man. I have seen him clad in all his majesty, an eagle feather, red paint, and bow and arrows, astride his shaggy pony with a haunch of venison for a saddle. I have seen him when he was very picturesque, begging for whisky and tobacco, and the next day massacring defenseless cowboys. I frankly confess that I liked him less than I did the coyotes. In those days, when first I knew the plains, the evidences of his depredations were on every side—here a child's rattle and charred bones among the cinders of a wagon, there a heap of shells on some lonely mound where the solitary hunter had made his last stand, and I did not love him. The plains of western Kansas and eastern Colorado were his great hunting grounds so long as the buffaloes lasted, that is, until 1876, and many were the forays he made upon the settlers, many the luckless victims of his treachery. Perhaps it has been only the bad side of his nature that I have seen, and for which the white man himself was largely to blame, but the ruthless destruction of the buffaloes, their unparalleled slaughter, was the only means that could have opened up the plains to civilization. The Indians would yet be savages were the buffaloes still abundant.

THE AIM IN HIGH SCHOOL PHYSICS TEACHING.

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Discussions in physics teachers' meetings usually relate to method. It has seemed to me that in order to reach an agreement or even an intelligent disagreement relative to methods we should discuss the principles that underlie our methods. I believe that if each one of us were to state frankly the thing he is actually working for we should find some diversity of opinion regarding the aim in high school physics teaching, One has accomplished his purpose if his pupils can repair the electric bells in their homes; another, if they can pass successfully the college or normal entrance examinations; another aims to prepare his pupils for future usefulness.

I believe that unity of aim is more to be desired than unity of method, because conditions, on which method depends, differ but child life is everywhere the same. Spencer says that every artist in the course of his education and after-life accumulates a stock of maxims by which his practice is regulated. Trace such maxims to their roots, and you find that they inevitably lead you down to psychological principles. The same is true of business men. Posted on the office desks of some of the business men in this city may be seen mottoes which they evidently regard as expressing the first principles of business success. Why should not teachers, especially teachers who are scientists, have their maxims, clear cut expressions of the principles by which their practice is regulated?

Can we find an expression upon which we may agree relative to the aim of high school physics teaching? I think we shall agree that the primary aim is not to prepare for examinations or for college entrance though these aims are sometimes forced upon us with such pressure as to take precedence over all others. Neither is it to train in manipulation. A workman who knows nothing of the principles of electricity can wire your house or repair your electric bell. Neither is the aim primarily to impart a knowledge of physics nor to prepare for any specific line of activity in later life.

The special aim of physics is derived from the larger aim of secondary education in general and this in turn from the aim of

*Read before the Physics Section of the Central Association of Science and Mathematics Teachers at the December, 1905, meeting.

all education, the aim of secondary education being specialized by the special phase of life dealt with and the aim of physics being further specialized by the subject matter.

From a study of fifty definitions of education, I find that each takes as its root idea one or more of four fundamental conceptions, viz: acquisition of knowledge, character building, development of individuality, preparation for rational living.

From our view point we may regard education as training a child to react intelligently upon his physical environment, one phase of rational living.

This implies intelligent thinking relative to the physical phenomena of daily life. The man who can think effectively is the man who is needed. Virtue, even, according to James, is a result of right thinking. I take it then that thought power is the thing to be sought after primarily.

I quote the following from the World's Work for July, 1905, as an example of the highest compliment that can be paid to any course of instruction. "What is the most practical result of a public school course as shown by boys and girls who apply to you for employment?" was asked a manager of New York's largest department store. "It has taught him to think," he answered. "With the school pupil of three years ago, it was necessary to teach every self-evident detail. The school pupil of today sees most of those details without being told. Individual thought seems to have replaced mechanical method."

Develop initiative. How many of us are teaching physics as we were taught. Somewhere, somehow we learned to adapt ourselves to new conditions, discovered that we could take up new problems and solve them, that is what our pupils will have to do. A business man of this city told me that the greatest lack in the boys who apply to him for employment is initiative.

An examination of a number of addresses by physics teachers covering a period of some ten years reveals the fact that thought power is with a few exceptions regarded as the primary aim. But what kind of thought power may we hope to develop in the high school pupil? It is here that high school physics differs radically from university physics. That which is intelligent thinking in the high school pupil would be extremely crude in the university student. "The method of research is not the method of immature mind." At any rate it is not the method of the mind of the average high school pupil. The heuristic method is not the only

method that leads the pupil to think. On the other hand, to quote Herbert Spencer, "To give the net product of inquiry without the inquiry that leads to it is found to be both enervating and inefficient. General truths to be of due and permanent use must be earned. The process of self-development should be encouraged to the fullest extent. Children should be led to make their own investigations and draw their own inferences. They should be told as little as possible and induced to discover as much as possible. The method of nature may be followed throughout. We may by a skillful ministration make the mind as self-developing in its later stages as it is in the earlier ones and only by doing this can we produce the highest power and activity."

At this point there has been a great deal of quibbling. On the one hand it has been urged that to give the pupil the facts and principles and expect him simply to "learn" them is to develop a dependent weakling. On the other hand it is said to be absurd to expect the pupil to rediscover the laws of physics.

Now, I shall state at once what I believe to be the right attitude in this matter. Let the pupil find out all that he can for himself in a reasonable time. Give him some facts and principles which he cannot find out for himself but lead him first to feel the need of them, and always keep his interest in advance of his knowledge. In many experiments, the teacher can remove the sources of error so that the truth will come to the pupil with all the force of original discovery and yet the work cannot be called discovery or research.

Tyndall relates this anecdote of Faraday: "I wished to show him a peculiar action of an electromagnet upon a crystal. Everything was arranged when, just before the magnet was excited, he laid his hand on my arm and asked, 'What am I to look for?' " and he adds, "Amid the assemblage of impression connected with an experiment, even this prince of experimenters felt the advantage of having his attention directed to the special point to be illustrated." How much more does the immature mind need direction. Eliminate for the pupil then the sources of error which he cannot himself overcome in a reasonable time, so that the laws so far possible will come to him with the force of original discovery. Tell him what he cannot find out for himself when he feels the need for the information and always keep his interest in advance of his knowledge. This method is not the text book method, not the heuristic method, but the method of self-impelled carefully directed effort.

The difficulty with us physics teachers is that we know our subject better than we know our pupils, and we are too often ignorant of our ignorance. We are nettled when the psychologist tells us that we are not obeying the laws of the adolescent mind. Now, we are familiar with the laws of matter and energy and we take certain laws into account in every experiment we preform in the laboratory or lecture room. The psychologist tells us there are laws of the mind which we must obey if we teach. We may go through the form of teaching and disregard these laws but we do not teach.

A fundamental law of teaching as of life is that only that occupation which begets an eagerness, a pleasureable activity, is really significant. I have avoided the word interest because that term is too often understood as a synonym for entertainment. If pupils do not relish the work in physics, it is a "grind." If they relish it because they can get through with very little effort, it is a "snap." It should be neither a "snap" nor a "grind." Neither of these has any disciplinary value.

Other fundamental principles that are frequently violated in our teaching and to a marked degree in our text books are these: that true teaching proceeds from the simple to the complex, from the concrete to the abstract, from the empirical to the rational. The way to meet these requirements is indicated by the historical development of physics. The psychologist tells us that the child mind follows the same order in its development as the mind of the race. In an ideal course the sciences would be interwoven so that the order of topics would follow the order of development of the child's appetite for knowledge and therefore, his capacity for assimilating that knowledge. Such a course being impracticable at present, the best we can do is to make a common sense application of the principles that may be learned from a study of the historical development of physics as far as is consistent with our present limitations. If we do this the plan of devoting the first fifteen weeks to mechanics, four weeks to heat and so on throughout the year will be pretty thoroughly broken up.

I might say that I am testing an outline based on the historical development of physics which has thus far proven more satisfactory than the old order from the point of view of the pupil's ability to assimilate the facts when presented.

Science is organized knowledge and knowledge thus gained is self-organizing, self-organizing because it is assimilated. We cannot organize the material for the boy and expect him to take it

as it comes, in the original package. *His knowledge must be self-organizing or unorganized.* A common fault of our physics teaching is that we teach too many principles with too slender a basis of assimilated fact. There appears to be a time limit in the distinguishing of separate impressions by the mind as by the eye. We crowd a new principle into the field of view while the preceding one is still on the retina of the mind and then we laugh at the confusion of ideas which we discover in the minds of our pupils.

Now a word as to some applications of the principles set forth in this paper. Examinations should be a test of thought power, not a test of memory. Incidentally, cribbing can be made very difficult if not impossible by examinations conducted on this basis. Problems that are merely curious have no place. Problems even that require thought but not thought regarding physical phenomena are out of place.

Showy experiments may be used to hold the interest of the class to its highest pitch but if these experiments stop with entertainment and do not lead the pupils to think, they fail.

It is turning aside from the true principles of physics teaching to go far into detail in the study of machines. Carry this study only so far as to illustrate the physical principles involved.

To summarize: Unity of aim in physics teaching is more to be desired than unity of method. Intelligent thinking regarding the physical phenomena of daily life is the primary aim in physics teaching. The method of attaining this end most naturally, and most surely is that of self--impelled, carefully directed effort. The order of topics best adapted to this end is indicated by the historical development of physics. Knowledge thus gained is self-organizing. Problems, examinations, subject matter are to be tested by this principle.

VITAL QUESTIONS FOR TEACHERS OF SECONDARY MATHEMATICS.

By J. B. Clarke,
Head of the Department of Mathematics, Polytechnic High School, San Francisco.

[CONTINUED FROM THE OCTOBER NUMBER.]

In this connection it would seem that we should pay more attention to the very beginnings of the mathematical course.

Much of the work in beginning classes is mere language work. No language work can properly be either hurried or crammed, least of all mathematical language work. The number of new concepts introduced to the mind of the pupil is large; he should have thorough and repeated drill on each before passing to the next. This requires that the instruction should extend over a considerable period of time, and not be crowded into the first few weeks of the first high school year. Time is required for the assimilation of mental as well as of physical food; it is as absurd to crowd the preparatory language work of the pupil's mathematical course into the first few weeks, as it would be to require him to consume a month's supply of food during the first week of the month. Two periods for twenty weeks is far better than five periods for eight weeks.

This language work is of such character that it can best be done in the grammar school, where there is vastly more time for mere drill work, requiring short lessons, frequent repetitions and constant reviews. If no formal demonstrations be attempted, (and none should be), this elementary instruction can readily be blended with the grammar school curriculum so as to add nothing to the labor of the teacher, while stimulating vastly the interest of the pupil.

By language work here I mean, not only the oral, but also the written, expression of the mathematical concept, whether in symbols or diagrams. As before intimated, the importance, both direct and indirect, of neatness, orderliness and accuracy in this written expression cannot be overestimated.

If another quotation from Laisant may be pardoned:

"The first notions of geometry should be given the child along with the first notions of algebra, succeeding closely the beginning of theoretical arithmetic. But just as there must be a preliminary preparation for arithmetic, viz: practical calculation, so theoretical geometry should be preceded by the practice of drawing.

"The habit, acquired in childhood, of drawing figures neatly and accurately will be invaluable in his later geometry. It is an error to define geometry as the art of correct reasoning on bad figures. We reason only on abstractions; no figure can be (absolutely) exact, but when the inaccuracy is too plain, when the drawing is poorly executed and appears confused, the confusion of form leads to confusion of reasoning, and tends to conceal (rather than to suggest) the truth. Indeed, cases occur in which a poorly drawn figure leads, by logical reasoning, to palpable absurdities.

"The first step in geometric education, accordingly, should be undertaken, as in the case of practical computation, only when the child knows how to read and write the language, i. e., knows how to draw." Advantage should be taken, in this drawing, of every opportunity to give the child all that he can assimilate in the way of geometric nomenclature.

The question as to what omissions from the conventional courses in algebra and geometry can be made without seriously impairing the efficiency of the work may perhaps be best considered by taking a view of the whole field. The classification of the subjects as:

Arithmetic the science of values,
Algebra the science of functions,
Geometry the science of form,

will perhaps best serve our purpose.

Definitions—Definitions are important, not so much to train the memory as to furnish the subject-matter—of the work. Mathematical concepts exist only in definition; clearness of concept cannot exist without accuracy of definition. Not only, then, should the definitions be thoroughly mastered when the concept is first introduced, but frequent application should also be made of Pascal's suggestion, to replace the term by its definition. This substitution the pupil should be ready to make at any time, and he should clearly understand that all the reasons that mark the course of a demonstration must ultimately reduce either to a definition, to mark the subject operated upon, or an axiom, to indicate one of the fundamental rules of operation.

While concrete illustrations should no doubt be freely used at the outset, resort to them should be less and less frequent as the work advances; until, at as early a stage as possible, they may be

altogether abandoned. Mathematics is not a physical science; it is a science of pure abstraction. The time must come, for example in the geometry of hyper-space, when concrete illustrations are no longer possible. The sooner the pupil is prepared to do without them the sooner will he be able to properly exercise the powers of imagination and of pure reasoning, and enter upon the real study of pure mathematics. It was the boast of Laplace that the *Mecanique Celeste* did not contain a single diagram.

A definition should be absolutely correct, so far as it goes; it must need no subsequent revision. It may, and of course often will be, used in subsequent generalization, but it should never require change.

The pupil entering upon a new subject is brought into mental contact with new concepts. He succeeds, usually not without great difficulty, in mastering the concept as presented to him. To ask him to disturb this concept (not to speak of asking him to efface it) is to completely upset him, to destroy his confidence, recently acquired, in mathematical certainty, and to leave him in a condition of mental incertitude that is absolutely demoralizing.

Reviews, of course, are not only helpful, but essential; on the Spencerian principle that there is nothing like continued and varied iteration for forcing alien conceptions on reluctant minds. But the review should be a re-view, not a change. If a notion can be presented at all at a given time it can be correctly presented; the concept once formed should never be destroyed.

Algebra. The idea of the function should, to my mind, be introduced as early as possible, and should be made the foundation of subsequent work. As soon as the pupil has become acquainted with the meaning of the signs and symbols and has had some drill in the evaluation of algebraic expressions he can grasp the idea of the function and can readily understand the two main questions that he will be called upon to answer, namely: Direct. What is the value of $f(x)$ when $x = a$? Inverse. What value of x will make $f(x) = b$ (b not necessarily o)?

The second question of course reduces by mere transposition to the important case, what value of x makes $f(x)$ vanish, and we are now ready for the equation.

The fundamental operations should all be directed to the end of handling the various functions with which the pupil will be called upon to deal. Thoroughness, accuracy, and reasonable speed should of course be insisted upon, but nothing should be

introduced that does not bear with practical directness on the ultimate aim. The equation should of course be introduced as early as possible, and factoring handled only with reference to its use in the solution of equations or such other work in the elementary theory of functions as it may be deemed advisable, or possible, to introduce. On the other hand, the solution of equations by factoring will in this view be preferable to any other method, and the sooner the pupil is introduced to the remainder and factor theorems (he having of course had the synthetic division needed in practical application of the latter), the better for his subsequent progress. The subjects of lowest common multiple and highest common factor need no further time, or attention, than is absolutely required in carrying out the main purpose. For this reason, the methods by factoring are the only ones that the high school pupil will ordinarily have occasion to use.

Should Sturm's theorem be taken up in the high school course, or the method of elimination by use of the euclidean process for finding the highest common factor, it will then be time enough to give this process. Complicated examples in fractions should be avoided; only such work being given as will bear upon the theory of functions as studied. In the case of concrete problems, the course should be devoid of mere mathematical puzzles, the problems being confined to such as will be of future value either in physics or mechanics or in the business of actual life.

It has recently been proposed by a writer in a high-class magazine to introduce the use of logarithms into the grammar schools. While this proposition is to my mind entirely too radical, yet there is no question that ordinarily the use of logarithms is too long delayed. In the ordinary course, the pupil does not reach the subject until it is too late to take any advantage whatever of its manifest utility in calculation. The average pupil on leaving the high school thinks that logarithms are used only in trigonometry. The experiment has recently been tried in one high school, at least, of introducing just enough of the theory of logarithms in the work of the first term to enable the pupil to to use them with readiness and accuracy in his applied mathematics.

The result is, I think, so satisfactory that the experiment will bear repetition.

Ignorance of logarithms is a distinct handicap to the student

of physics and mechanics, and the mere fact that the suggestion has been made to introduce the subject of logarithms into the grammar school shows that there is a demand for getting it into the algebra course as early as possible.

Geometry. Much time is wasted in work on so-called originals, which by many teachers are made a fetich. A proposition whose solution is given by the teacher, or by one or two pupils out of a class of forty, for the amazement of the interested dullness, or the vacant stare of the apathetic indolence, of the class, to be copied mechanically as an exercise in penmanship and drawing, is no more an original than any of the propositions in the regular text.

The object of preparatory instruction is two-fold (a) to put the pupil in possession of certain facts; (b) to develop in him mathematical power. The ordinary method of handling so-called originals does very little toward accomplishing the first object and practically nothing toward attaining the second. Better omit them to a great extent from the regular course, and develop the mathematical talent of the class as a whole by laboratory exercises.

In physics and chemistry we give a certain part of the time to the study of principles, and the remainder to the application of these principles in the laboratory. So, in mathematics we can profitably devote the bulk of the time to the study of principles, and the remainder to real, and not affected, application of these principles.

The best modern geometrical thought never reaches the average pupil. Provision should be made in the high school curriculum for the modern projective geometry. The advantages of its methods over those of Euclid, it is, of course, unnecessary to state. Every teacher, however, has heard the complaint from the pupil that he likes algebra because he has always had an idea of what was coming after the work on which he was for the moment engaged, and could see a connection between the work of today and the work of yesterday. In other words, he caught the principle of continuity running through his algebraic work. But in geometry, the theorems seem to be merely disconnected statements; no one suggests another. He might understand a geometrical proof as he read it in the text, but could get no idea as to how this proof was originally thought out. If the solution of a hundred problems were explained to him he would be just

as much at sea on the method of attacking the one hundred and first as he was in the case of the first. This difficulty, of course, can be, to a great extent, remedied, but not wholly removed.

On the other hand, the methods of modern projective geometry are as connected and continuous as those of the analytical geometry. In other words, they have precisely that line of continuity which the pupil grasps in the algebra, but fails to grasp in the euclidean geometry as ordinarily taught. Given a problem, the method of attack is reasonably certain at the outset, and having followed the certain method, we are just as sure of reaching the solution as if we were required to derive the equation of a curve from its definition, or the equation of the tangent from the equation of the curve. Aside, therefore, from the many beautiful theorems peculiar to modern geometry, and its important applications, (as recently developed), in physics, for the sake of its methods alone, the power and the breadth of view that it gives to the student, it should occupy a place and an important place, in the high school curriculum.

As to the place mathematics should occupy in the course of study, we are confronted with considerable diversity of opinion. This arises to a great extent, at least, from the fact that the word mathematics does not convey the same idea to the minds of all that use it. To many, the term is practically synonymous with mere calculation; not necessarily arithmetical, but still mere calculation. To most people it is looked upon as a mere step in the preparation for some mechanical or engineering profession. Properly considered, it is, of course, a science existing through and by itself alone. Other sciences must lean on mathematics, but mathematics leans on none. The fact that the physical sciences cannot exist without mathematics no more makes mathematics a mere preparatory study than the fact that English is indispensable to the ordinary American student, in any branch, makes English a mere preparatory study. And English will certainly be admitted to be a culture study. Considered as "a system of reasoning by definite or fixed processes on certain concepts, (themselves existing only in definition) called mathematical concepts," it presents the highest degree of intellectuality. If culture be the power of using harmoniously and with effectiveness one's whole mental equipment, then there can be no more important culture study. And this indicates my opinion of the place it should occupy in the school curriculum.

POLAR TRIANGLES.

By Wm. F. Rigge, S. J.,

Creighton University, Omaha, Neb.

Polar triangles are apt to prove most uninteresting to the student of spherical geometry. The cause of this apathy is to be found as well in the want of a globe upon which these triangles may be shown in their true form, as in the little use which they seem to serve.

As a slated globe is not likely to be within the reach of most instructors, a good and probably more effective substitute for it may be made of ordinary cardboard by cutting out a number of circles or parts of them with the same radius, say, of six inches. On one of these circular pieces, Fig. 1, we draw two radii HC and OC at an angle equal to one side *a* of a spherical triangle OHN and then two other radii, CA and EC, at right angles to the first two. We construct similar sectors for the other sides *b* and *c*, of the triangle. Then cutting out a slot half way along these radii, HC, OC, NC, of the width of the cardboard, and removing the outer half of a radius in one sector and the inner half in another, we can fit these pieces of cardboard together and secure them in their position with a few stitches of thread. Having computed the angles of this triangle, HON, its polar triangle may be constructed in a similar way. It may be necessary, however, to cut a few additional slots into the cardboard sectors in order to fit them together.

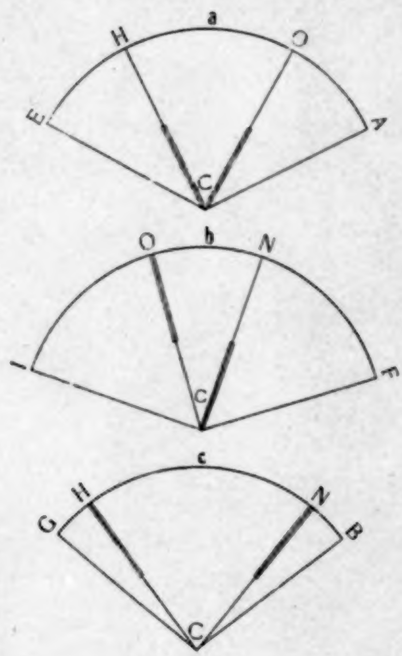


Fig. 1

In this way the student can see at a glance that the sides of the triangles are arcs of great circles and that their planes intersect at the center of the sphere. He will see the meaning of

the appellation polar, and can readily understand all the propositions in the geometry relating to these triangles. It is evident that other propositions in spherical geometry can be illustrated by similar models. And I dare say that the instructor himself will even prefer the cardboard polar triangles to a slated globe.

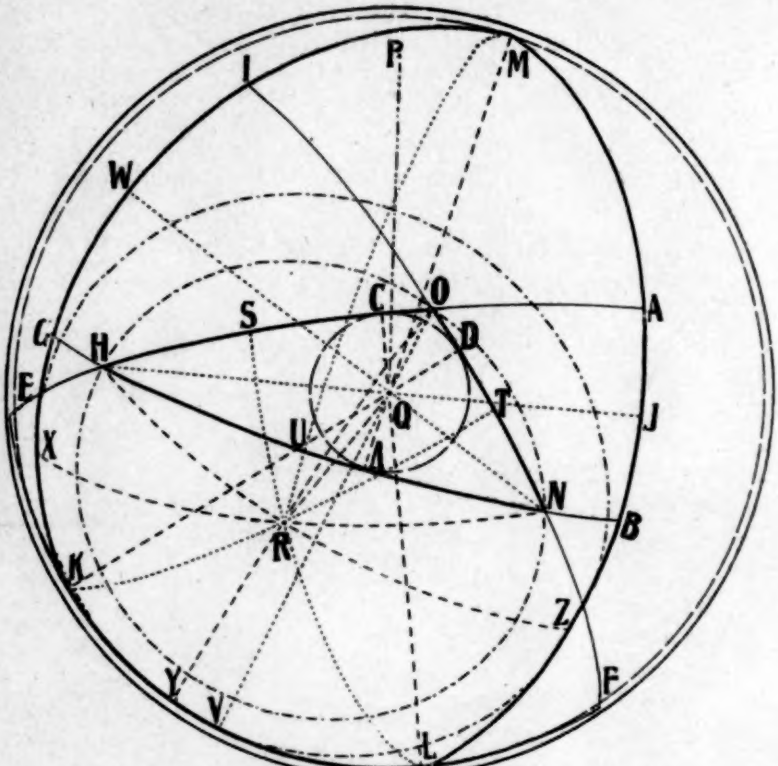


Fig. 2

Another substitute for a slated globe is a cheap six-inch terrestrial globe such as can be bought for 35 cents or less. Pins may be stuck into it and connected by colored strings, and the examples, especially in trigonometry, may be made very practical by taking known cities as vertices of the triangles. The holes made by the pins do not disfigure the globe; indeed, it is sometimes difficult to find them even in the oceans.

In order to show the use of such a globe I will give the data of a practical example. I have taken Omaha, Honolulu, and Panama as the vertices of the triangle and denoted them by the letters O, H, N, reserving P for the north pole. I will give the latitudes and longitudes of these and other places later.

Fig. 2 will serve to fix our ideas as to the meaning and approximate location of the points to be mentioned. This figure is an orthographic projection of the terrestrial sphere as seen from the zenith of the point Q, the center of ahe circle inscribed in the triangle OHN. The triangle KLM is polar to the original triangle OHN. The reciprocity and other properties of these two polar triangles may readily be seen from the figure by anyone conversant with the subject. That each side of one triangle is the supplement of the angle opposite to it in the other, would seem to be the only property that is generally mentioned in textbooks. The interest of the student in polar triangles will certainly be awakened if some of the other properties are also illustrated. Thus, the point Q, which is the pole of the circle inscribed in the triangle OHN, is also the pole of the circle circumscribed about the triangle KLM, and the radii of these two circles are complementary. Similarly, R is the pole of the circle circumscribed about HON and of the circle inscribed in KLM, and the radii of these circles are complementary. The arcs of the great circles drawn from the vertices of one of these triangles through the pole of its inscribed circle, bisect the angles in this triangle and the opposite sides of the other triangle: HQJ, OQV, NQW, KRT, LRS, MUR. The arcs of the great circles drawn from the vertices of one triangle through the pole of its circumscribed circle, intersect the points at which the sides of the other triangle are tangent to its inscribed circle: HRZ, ORY, NRX, KQD, LQC, MQΛ.

The positions of the points in the example selected are as follows:

			Latitude		Longitude	
Vertices of Original Triangle	Omaha	O	+ 41°	16′	+ 95°	57′
	Panama	N	+ 8	57	+ 79	31
	Honolulu	H	+ 21	19	+157	52
Vertices of Polar Triangle		K	− 21	14	+166	0
		L	− 48	43	+ 94	15
		M	+ 68	7	− 33	34
Middle Points of the Tides		S	+ 35	16	+130	13
		T	+ 25	20	+ 86	37
		U	+ 19	1	+117	21
		V	− 40	36	+137	11
		W	+ 43	36	+178	8
		J	+ 18	44	+ 60	16

Intersection of Tides of Original Triangle produced with Tides of Polar Triangle (produced)	E	− 0	50	−174	47
	A	+ 33	26	+ 52	59
	I	+ 65	40	−168	56
	F	− 41	12	+ 56	9
	G	+ 19	49	+172	46
	B	+ 3	49	+ 66	22
Radius of Circle Inscribed in OHN				11	57
Radius of Circle Circumscribed about KLM				78	3
Pole of both Circles	Q	+ 28	50	+103	54
Radius of Circle Circumscribed about OHN				39	29
Radius of Circle Inscribed in KLM				50	31
Pole of both Circles	R	+ 7	43	+119	25
Points of Tangency of the Inscribed Circles	C	+ 40	44	+105	42
	D	+ 34	43	+ 91	38
	A	+ 17	2	+107	8
	X	− 2	42	+171	6
	Y	− 34	3	+144	15
	Z	− 13	0	+ 74	0
North Pole	P	+ 90	0		
Symmetrical Antipodal Triangle	O′	− 41	16	− 84	3
	N′	8	57	−100	29
	H′	− 21	19	− 22	8
Pole of Circle circumscribed about Antipodal Triangle	R′	− 8	43	− 60	35

It is, of course, left to the judgment of the instructor to use as many of the points given as he may think fit, or even to devote a globe permanently to the illustration of this example.

IN WHAT ORDER SHOULD PLANT AND ANIMAL GROUPS BE STUDIED?

By Amelia McMinn,

West Division High School, Milwaukee.

Probably we all agree on the theoretic value of using the so-called "logical" order for a study of animal groups and use it during a large part of the year's work. But for beginning I have found nothing else so satisfactory as insects when used from a Natural History standpoint. After several years of adherence to the logical order I returned three years ago to this "irregular order," following the work on insects with a study of types from each phylum in logical arrangement.

There are several advantages to be gained by using this plan. First, pupils can get many zoological conceptions by means of their unaided senses. They are young when they come to us. A large proportion of them have their eyes nearly closed to the world of life about them, their childhood's power of seeing almost educated away. They have quite a task before them if that useful power of observation gets the development which a study of animals ought to give, and it seems to me that we have no right to require its first exercise to be dependent upon the use of a difficult, new instrument, no matter how interesting. The interpretation of what is seen in one-celled animals under high magnification is difficult for us—then how much more difficult for those just beginning to understand the use of a microscope! When found necessary or helpful during the course on insects, the use of this instrument may easily be learned, and the external parts of insects certainly furnish ideal objects for practice in the mental interpretation of what magnification teaches, for they can be seen with the naked eye or with a hand lens.

Again, our pupils must get practice in drawing, description, and comparison, and insects furnish excellent specimens for the beginning of this work, as so much can be done without dissection. Now that we recognize so many more interesting departments of work in this study and many more useful kinds of manual training, we are rightly leaving difficult feats of dissection to be carried on in college rather than in high school. Hence, comes the value of beginning with highly specialized forms whose life, work, and adaptations can be fairly well understood by the study of external features chiefly. One feels the usefulness of

this plan especially when he sees the difficulty with which many high school students learn to make zoologically accurate drawings.

But more important than either of these reasons is the great advantage of having good living material in its season, and of studying in the laboratory those animals which are most prominent in field study. My experience has been that field and laboratory work help each other much more when carried along together as far as possible, and I doubt the practical wisdom of trying to carry on a logical sequence of studies by going from *Paramecium* to caterpillar, then back to *Amoeba* and dragon-fly. If the brightest pupils keep a thought of continuity in their animal study, a conception of the increasing complexity of the animals which they work over, it will be only by means of elaborate explanation on the part of the teacher. Is there not danger, too, that the work on insects will be badly slighted? Will not the laboratory work be an incentive and an eye-opener, and make it possible for our boys and girls to get a much better first-hand knowledge of a very important group than they can when the insect study is but an incident to the regular work? I feel almost certain that something will surely suffer by a use of this "incidental" method, and so advocate taking the insects when they are abundant and most interesting.

In botany I prefer to begin with seeds, or with a few fruits and their seeds, and to follow this study with the general morphology and physiology of higher green plants, exclusive of reproduction. After this follows, of course, a survey of the plant kingdom beginning with lower organisms and ending with the spring flowers of the locality. All reasons for using an irregular order in zoology apply equally well to this study, and especially worthy of consideration seems the fact that this arrangement fits with the seasons. Moreover, there are some physiological processes, for example, photosynthesis and irritability, which can be more satisfactorily studied by experiments on larger plants and the ideas thus gained transferred to simpler organisms with economy of time and mental effort. This statement scarcely needs elaboration or illustration to those who have taught plant physiology to high school classes, certainly not to any who have tried to carry a class through the opening chapters of Bidgood's Biology.

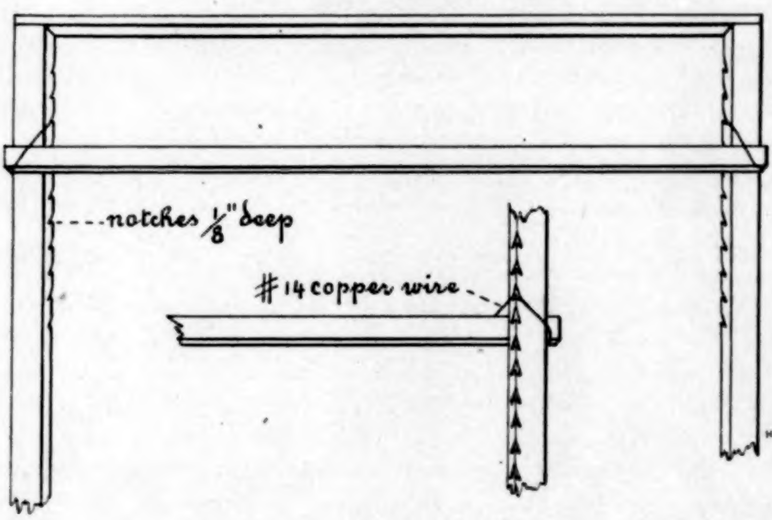
On the other hand, reproduction by spores and sexuality in

Spermaphytes can be approached better through the lower forms, and hence may easily be omitted from the first part of the course to be taken up during the synthetic study of types from each large group.

Finally, since this is not a debate, I am willing to overthrow all my arguments by saying, "What does it matter anyway?" Certainly, if a teacher's appointment depended upon this question of order, the wise school board would ask not, "What order do you use?" but, "Have you a well-pondered reason for any special arrangement?" For any teacher with convictions can do better work by using the illogical arrangement of Tenney's old textbook than by blindly following another's lead against his own better judgment.

A SIMPLE MEANS OF ADJUSTING THE CROSS-BAR FOR A LABORATORY-TABLE RACK.

By C. M. Brunson.
Toledo Central High School.



The above rack can be made by anyone with a little skill in the use of carpenters' tools. The device for adjusting the cross-bar is inexpensive, easily adjusted and very efficient. A slant can be given to the bar if necessary—i. e., in the problem of parallel forces.

SOME AGRICULTURAL PRODUCTS OF THE TROPICS.

By Mel T. Cook,

Chief of the Department of Plant Pathology, Cuban Agricultural Experiment Station.

II. TOBACCO.

America gave to the world many important plants; and in fact we are indebted to the discovery of America for the greater part of the family Solanaceae. Strangely enough, this family contains plants which are among the most useful to man and also some which are very injurious. It includes some of the most important food plants and some of the most deadly poisons in nature. The so-called Irish potato (Solanum tuberosum) of Peru, the tomato (Lycopersicum esculentum), the egg plant (Solanum esculentum), and the pepper (Capsicum annuum) may be mentioned among those which are especially valuable; while the deadly nightshade (Atropa belladonna) and tobacco (Solanum tobaccum) may be mentioned among those which contain violent poisons. Many other members of this family are of considerable importance and still others under cultivation may prove valuable.

Tobacco has become one of the great economic products of America and at the same time one of the curses of the human race. Despite the fact that it may be considered a curse, its abolition, were it possible, would cause untold misery and suffering. Thousands of people make their living solely by its cultivation, manufacture or commerce; while untold millions use it in one or more forms.

There is little or no doubt as to the origin of tobacco. When Columbus first came to America he found the Indians using it and old records show that it was introduced into Europe in 1558 by Francisco Fernandez, a physician who was sent to Mexico by Phillip II to make a study of the vegetable products of the country. Its dissemination throughout Europe was largely due to John Nicot, the French Ambassador to Portugal, and the generic name Nicotiana was created in his honor. In 1586 the plant and outfits for smoking were taken to England by Ralph Lane, the first governor of Virginia, and Sir Francis Drake, who presented them to Sir Walter Raleigh. The anecdotes concerning its use by Raleigh, the story of its spread throughout Europe and of its early cultivation in Virginia are familiar to the American public school children.

TOBACCO.

Tobacco is now an important agricultural product throughout the Southern states and in many localities in the Northern states, especially in Ohio, Pennsylvania, and Connecticut. But probably the greatest tobacco producing country of the world is in the western part of Cuba, known as the "Vuelta Abajo" district. Tobacco may be grown in the open or in the shade, dependent upon the quality and the amount of wrapper leaf that the grower hopes to produce. In recent years the growing of tobacco under cheese cloth shade has increased rapidly until at the present time large quantities are grown in this manner. Tall posts are set at regular intervals over the fields and wire stretched across them. Over this the cheese cloth is stretched and brought to the ground around the margins of the fields. In this way large fields, frequently as much as forty acres are put under a single tent. In Cuba the tobacco is grown in winter and often two crops occasionally as many as four are taken from the land in a single season. It is a very expensive crop, requiring much time, labor and experience.

TWO PIECES OF LECTURE APPARATUS FOR LANTERN DEMONSTRATION.

By Will C. Baker,

School of Mining, Queen's University, Kingston, Ont.

The following notes contain descriptions of the adaption of two familiar experiments for use in the projection lantern.

I. PITH BALLS FOR THE LANTERN.

Experiments with pith balls require a lantern to magnify the small motions so as to make them visible to a class, even in well lighted class rooms. The chief trouble in using pith balls in a lantern is that the charged balls fly to the condenser and other parts of the lantern, thereby not only getting out of focus but losing their charges as well. These troubles disappear with the use of a double suspension for the balls and a guide strip to keep their displacements parallel to the condenser. The device will be most readily understood by reference to the sketch (Figure 1.) *A* is the guide strip, screwed to the base board *B* 30x10 cm.)[1] *C* is a fixed upright (50 cm. high) carrying two fairly stout copper wires (15 cm. long and inclined to one another at 60°). From the outer ends of these wires is supported by silk fibres[2] (35 cm. long) one of the gilt pith balls. The second pith ball is similarly supported from an upright in the sliding piece *D;* the wire ends of which are a little farther apart than those of the fixed support[3]. By bending the copper wire arms, the balls are readily adjusted so that they hang at the same height and so that both swing in the same plane parallel to the condenser.

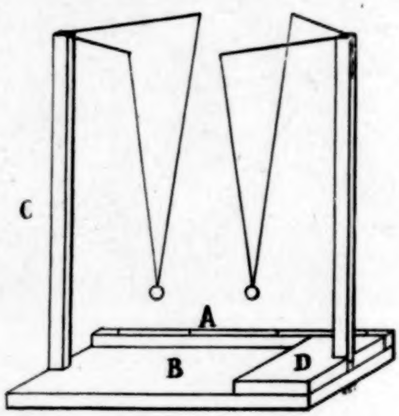


Fig. 1.

With such a piece of apparatus all the usual pith ball experiments may be performed in the lantern with comfort. When only

[1] These dimensions refer to the apparatus in this University, for a lantern with an 11 cm. condenser.

[2] By untwisting a meter of white silk twist, one may easily draw long silk fibres from the untwisted strands.

[3] This enables the supports to be slid past one another when desired.

one ball is required the movable support may be lifted to one side. When two balls are used the guide strip enables the lecturer to keep them both in focus while moving them together or apart.

II. A LANTERN DEMONSTRATION OF THE LAWS OF ELECTROSTATIC INDUCTION.

The device described below has given much satisfaction in recent elementary lectures in this university. *A* and *B* (Figures 2 and 3) are gold leaf electroscopes made of two strips of thin

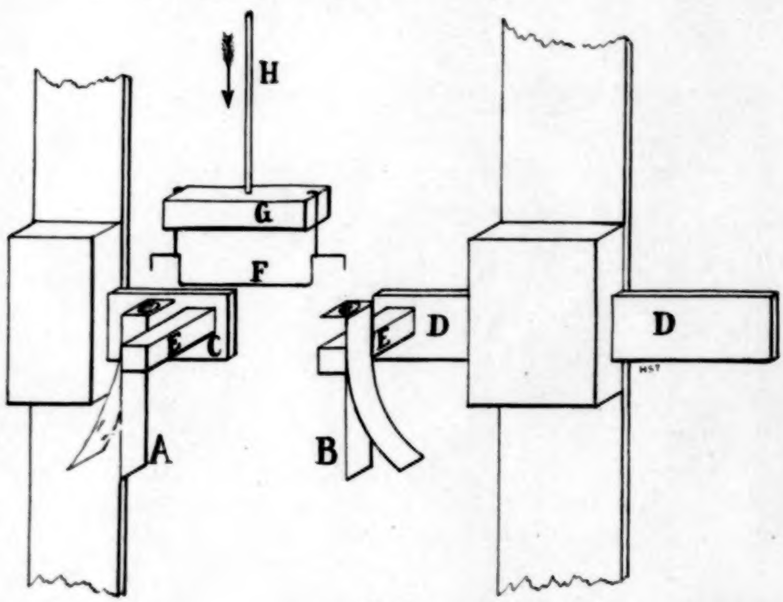


Fig. 2.

brass (4½x½ cm.); the top half centimeter of each is bent at right angles and these parts are slightly cupped to receive the ends of the connecting wire, to be described later. The brass strips are attached to the glass arms[4] *C* and *D* by pieces of sealing wax (say 0.7x0.7x3 cm). The arm *C* (2x8x0.2 cm.) is attached by a tight clamp to the inside of the wooden case (see figures 2 and 3). The arm *D* (2x15x0.5 cm.), one end of which projects outside the case, is held by a loose clamp so that it may be pushed forward until the two electroscopes are in contact. *F* is a wire (bent so as to hang in a stable position)

[4] The glass is to provide a transparent support. The sealing wax provides the insulation.

that may connect the electroscopes. This wire is suspended by silk threads from the piece of sealing wax, *G*, which in turn is cemented to the wire *H*. *H* projects through the bush on top of the box and enables the lecturer to raise or lower *F* at will. The set screw enables *H* to be clamped at any height. An earth-connected strip of tin *K* is also added to increase the charges induced on *A* and *B*.

The whole apparatus is enclosed in a wooden box (20x30x8

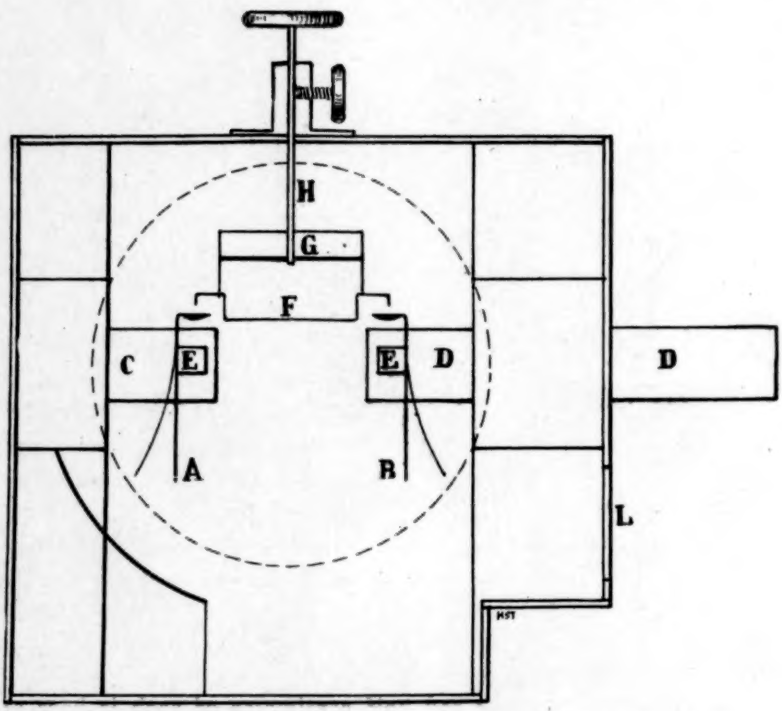


Fig. 3.

cm.) having the two largest sides partly of glass. A notch in one corner (figure 3) is necessitated by the construction of the writer's lantern. An opening (5x7 cm.) in left at *L* (figure 3) for the introduction of the charged body that is to cause the induction. The dotted circle (figure 3) shows the size and position of the lantern condenser. The gold leaves are most conveniently attached by short strips of gummed paper, as the straight edge of the paper causes the gold foil to bend along a line that makes a good hinge.

The demonstration is made as follows: After drawing the attention of the class to the electroscopes and the connecting wire, the latter is lowered until it puts *A* and *B* into electrical connection. A rubbed ebonite rod is introduced through *L* until the excited part is just below *B*. Care must be taken that no spark passes. Both electroscopes deflect. Still holding the rod under *B*, the connecting wire *F* is lifted, isolating the induced charges. If now the excited rod be removed the electroscope remains equally deflected and when the rod is brought down *outside the case*, so as to be above the electroscopes and equidistant from them, the leaf of *B* falls, while that of *A rises;* showing negative electricity on the latter and positive on the former.[5] Thus the law of the sign of the induced charges is shown. Next if, by means of the projecting arm *D*, the electroscope *B* be pushed forward until it touches *A* the two charges are found to neutralize one another, proving them not only of opposite sign but also of the same magnitude.

Of course this latter fact may be obtained by simply showing that both leaves rise when the excited rod is held under *B* and both collapse when the rod is removed, (*F* being down during the entire operation and the system being initially unchanged). Experience shows that the procedure first described gives the class a livelies sense of the essential points than the latter, simply because in the former their attention is directed to one point at a time.

It is the practice of the writer to give the second demonstration only after the full law is understood by the class.

The production of caoutchouc by chemical means has, indeed, virtually been accomplished in its formation from the isoprene. The exact nature of this change has still to be determined. When this has been done it will remain only to cheapen the cost of production to make the manufacture of synthetic rubber a purely practical problem. Still, the great extension of rubber planting which is now taking place is warranted by the present demand for the material. It has also to be remembered that the actual cost of producing raw rubber will probably be reduced, and the market price of rubber may eventually be so considerably lowered that, as with quinine, the synthetic production could not be profitably carried on. That is a question which involves many factors at present unknown, and only time can decide.—*Scientific American Supplement.*

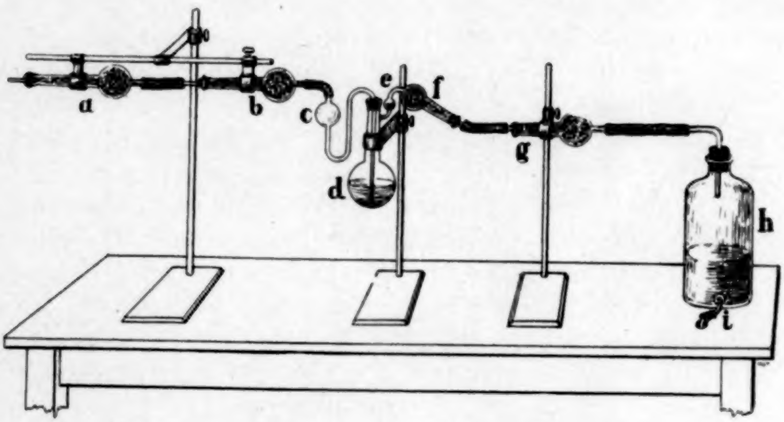
[5] It must be shown first of course that when a charged rod is brought over a charged electroscope: the leaf rises when the charges are similar but falls when the charges are dissimilar. This may be taken as an experimental fact and the explanation left until the law of induction has been established.

THE ESTIMATION OF CARBON DIOXIDE IN MINERALS AND ROCKS.

By Nicholas Knight,

Cornell College, Mount Vernon, Iowa.

The Fresenius method for the estimation of carbon dioxide in a mineral or rock, the one usually described in the text-books, is somewhat complicated and difficult of manipulation. An undesirable feature is the long series of U-shaped tubes with rubber connections through which it is possible that the carbon dioxide may escape. Everyone who has made ultimate analyses by com-



bustion understands how constant a source of error the joints are and how carefully one must guard losses through the walls of rubber tubing.

A much simpler method was devised by Robert Bunsen, although for some reason it is not usually described in the text-book literature. The essential features are shown in the accompanying illustration. A gram of the finely powdered substance, so fine as not to feel gritty when placed between the teeth, is weighed into the flask *d*. The bulb *c* is nearly filled with a mixture of one part hydrochloric acid and three parts distilled water. The bulb *e* contains cotton which assists in condensing andabsorbing the vapor. Attached to the bulb is a small tube *f* filled with fused calcium chloride. The apparatus from *c* to *f* inclusive is carefully weighed. By means of rubber tube attached to the calcium chloride tube *f*, the dilute acid is started into the flask *d* by suction with the mouth. When all the liquid has passed over, the ap-

paratus is held in the hand and gently warmed until the powder is dissolved or effervescence ceases. The apparatus is then connected with two freshly filled calcium chloride tubes *a* and *b* on one side, and a calcium chloride tube *g* and aspirator *h* on the other side, as shown in the figure. Air is drawn through the apparatus for about twenty minutes, while the flask *d* is immersed in a beaker of distilled water to cool it. The apparatus is carefully wiped with silk and weighed, the loss, of course, representing the amount of carbon dioxide. The apparatus is gently warmed again, and the air aspirated through as before while the flask is in the beaker of distilled water. A weight that is practically constant is readily attained.

It might seem that there would be a tendency to get too high a result on account of the escape of moisture and hydrogen chloride, but such is not the case, providing the rock substance has been sufficiently pulverized and the calcium chloride in tube *f* is of good quality and is changed sufficiently often to keep it in proper condition; besides, the acid becomes further diluted as soon as it begins to act on the powder, and at first the action takes place with very little heat. There is not much difficulty in securing a result that differs not more than one-tenth per cent from the theoretical; indeed, in the majority of determinations, exactly 44 per cent of carbon dioxide is obtained in Iceland spar, or within .02 to .03 per cent of that amount. In the specimen of argillaceous limestone which was the subject of the co-operative analysis, the experts at Washington obtained 30.59 per cent and 30.77 per cent of carbon dioxide respectively; while by the Bunsen method, one of our students obtained 30.76 per cent, before the analysis of the limestone was published in the February number of the *Journal of the American Chemical Society*. We ordinarily use from eight-tenths to a gram of the rock powder. When it is desirable to make a carbon dioxide determination in a sulphide like chalcopyrite or smaltite, it is necessary to prevent the escape of sulphuretted hydrogen as this would give a result too high. This is accomplished by the use of dilute sulphuric acid instead of hydrochloric acid. If there is still an odor of sulphuretted hydrogen, a small quantity of powdered copper sulphate, ferrous sulphate or potassium dichromate is introduced into the bulb with the powdered rock. The carbon dioxide can be easily determined by this means.

After many years of trial, the writer commends this method on account of its simplicity and accuracy; even the student with but little quantitative experience can use it with success. The ability to secure good results increases one's interest in quantitative work. The ordinary high school student who has access to a fairly good analytical balance would have no serious difficulty with this determination. In our laboratory we use this method in the analysis of Iceland spar, dolomite and siderite.

THE INDEX OF REFRACTION. (SNELL'S LAW.)

By John C. Shedd,

Colorado College.

In the March number of School Science and Mathematics, Dr. Millikan, in an interesting article on "Tendencies in Physics," gives a list of "bugbears" which beset the pathway of the physics teacher. As bugbear No. 12 he mentions the presentation of the *index* of *refraction* as a *ratio of sines* instead of a *ratio of velocities.* Such a change as he suggests has somewhat to commend it and perhaps ought to be adopted were the teacher limited to a choice between the two.

It must be remembered, however, that definitions and laws, like the one under consideration, have a history that is as truly a part of the science of Physics as are the finished expressions themselves. Sometimes the definitions, in their wording, suggest this history and are an epitome of it, so that on reading them the mind casts a bird's-eye view backward over the sometimes tortuous, but always interesting, historical progress of the subject. It would surely be a loss to lightly throw aside the historical content of the definition or law merely to make room for a more recent or even more salient expression of the same truth. Will it not better be to frame a second definition which expresses the same truth from the new viewpoint, thereby leaving unmarred th old, and enriching it by the new?

The law in question is one of this class—it bears the name of one of the early workers in Physics, and is in its wording, an epitome of the knowledge of optics up to the time of its framing. To the lover of Physics its story gives the opportunity of engaging the interest of the pupil and of making the subject a living

instead of a dead thing. It would indeed be a pity to lose such a landmark from the landscape of the science.

The better to illustrate my point let us for a moment look at the history of this law.

The bending or "refraction" of a beam of light as it passes from one medium to another must have been noted in the very earliest times. Claudius Ptolemy (A. D. 139) was the first to leave any record of observations. From him we have tables of what we now call the angles of incidence and refraction. Eleven centuries later Vitillio (A. D. 1278) also left similar tables. The law which lay hidden in these observations was not detected by even so keen a mind as Kepler's and was not discovered until four centuries later Willebrod Snellius "observed* that if the refracted ray and the incident ray continued through the point of incidence be intercepted by any line parallel to the normal to the surface at the point of incidence, the length of the intercepted portion of the refracted ray is in a constant ratio to the length of the intercepted portion of the incident ray." Snellius died without publishing his conclusions and the world first knew them from the pen of Descartes in 1637. Descartes is supposed to have had access to Snell's papers and if so found the following form of the law,† "For the same media the ratio of the cosecants of the angle of incidence and of refraction retain always the same value." He changed the wording and gave the law the form as we now have it as follows: "The incident and refracted rays are in the same plane with the normal to the surface; they lie on opposite sides of it, and the sines of their inclinations to it bear a constant ratio to one another." The wording of Descartes is a more comprehensive and better one than that of Snell, and perhaps he thus justified himself in omitting to give due credit to his predecessor. At all events the law was long known as Descartes' law and only in comparatively recent times has honor been given where honor was due.

Snell's law was published in 1637, and, as we have seen, relates only to the refraction or bending of the ray. It was fully developed fifty years before. Romer, in 1676 made his classic determination of the velocity of light in interplanetary space. It was not until nearly two centuries later (1850) that Foucault announced the experimental determination of the velocity of light

* Preston's Theory of Light, page 9.
Cajori's History of Physics, page 76.

in water and the fact that the ratio of the velocity in air and water is the same as required by Snell's law. The history of the determination of the velocity of light is an intensely interesting, but an entirely distinct, story from that of the law of refraction, and is worthy of a monument of its own. Such a formula, summarizing the work of Arago and Foucault, would be a gain to scientific clearness and would stand in Physical Optics as the law of Snell does in Geometrical Optics. The question then arises, how can we express the so called law of refraction so as not to confuse it with Snell's law and yet bring out the law of velocities in two media?

My answer is as follows: The velocity of light in the free ether is the same for all wave-lengths and is taken as the standard velocity. It is found by experiment that the velocity in material media is less than in the free ether, and depends upon the wave-length. If now we construct a table of relative velocities we obtain what may be called *the coefficient of retardation* of the given medium. This coefficient is the term by which the velocity in the free ether must be multiplied to obtain the (generally) reduced velocity in the given medium. The fact that the coefficient of retardation is the reciprocal of the index of refraction at once shows its relation to Snell's law and keeps it distinct from it. The following is such a table:

Substance.	Index of Refractions.	Co-efficient of Retardation.
Water	1.336	0.748
Crown Glass	1.5	0.666
Flint Glass	1.585	0.632
Ice	1.31	0.764
Diamond	2.47 to 2.75	0.405 to 0.364

The index of refraction is expressed by the equation

$$u = \frac{\sin i}{\sin r},$$

while the coefficient of retardation is given by the equation

$$V_1 = KV_0 \text{ where } \begin{array}{l} V_1 = \text{velocity in given medium.} \\ V_0 = \text{`` `` vacuum.} \end{array}$$

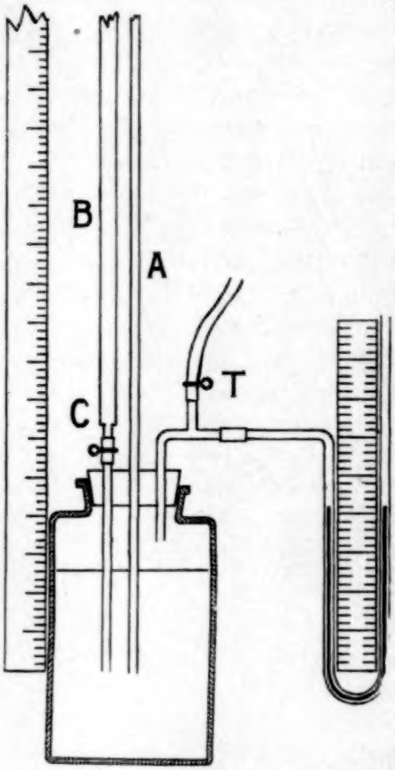
Since they represent different, though related, ideas, they should be taught as separate quantities. If the teacher cannot take the time to include both in his teaching I would agree with Dr. Millikan that the ideas involved in the Coefficient of Retardation are to be given precedence over those represented by the Index of Refraction.

APPARATUS FOR DEMONSTRATING LAWS OF LIQUID PRESSURE.

By H. Clyde Krenerick,

J. Sterling Morton High School, Berwyn, Ill.

With diagram and print, the apparatus will need but a brief description. The tubes, *A* and *B*, are a meter or more in length. Tube *B* is of two parts, so that the upper part can be replaced by tubes of different diameters. The liquid used is a very dilute solution of potassium permanganate.



The laws which, I believe, can be satisfactorily demonstrated are: that the pressure is proportional to depth, or water-head; that it is proportional to the density of the liquid; and that it is independent of the shape of the containing vessel.

To demonstrate the first law, use but one tube, shutting off the other by means of the clamp *C*. By forcing air into the bottle through the rubber tube *T*, the liquid can be raised to any desired height in *A*. When the clamp in *T* is closed, the column is held, and the readings can then be taken. By varying the height of the column, a series of readings can be obtained. Knowing the use of the open manometer, the pressures can be secured, and the relation between depth and pressure determined.

To show the effect of a variation in density, fill the tube *B* with different solutions, the densities of which have been previously determined. The tube is then connected, and the column lowered to a definite or a constant height. The readings of the manometer for the different solutions, show the expected relation between pressure and density. Care must be taken not to lower the liquid until the entire column is of the solution.

The independence of the pressure from the shape of the vessel is easily shown by replacing the upper part of B with other tubes of different diameters, especially with one in which several bulbs have been blown. It is well to experiment also with the tube inclined to the vertical. I believe the most satisfactory and interesting application of the apparatus is the demonstration of this hydrostatic paradox. Students after studying the text are sometimes disinclined to believe the principle in all cases. I usually disconnect the larger tube and have some student, by blowing through the tube T, force the liquid as high as he possibly can in the one tube. When the second and larger tube is also in communication with the bottle, he is very much surprised in finding that the two columns can be raised as easily as the one.

The fact, that in most text-books the order of topics is such that manometers and related matter are presented somewhat later than the principles of liquid pressure, may cause the application of the manometer to be an objection to the use of the apparatus. If such a piece can be obtained, this objection can be prevented and the apparatus very much simplified by connecting directly to the bottle a small pressure gauge in place of the manometer.

Teachers College, Columbia University, has recently issued a report by Miss S. R. Benedict on "The Development of Algebraic Symbolism from Paciuolo to Newton." This valuable monograph, prepared entirely from original sources, will be sent gratis to any teacher of mathematics who will write to Professor D. E. Smith, Columbia University, New York City.

GRAPHIC METHODS IN ELEMENTARY ALGEBRA.*

By William Betz.

East High School, Rochester, N. Y.

All human thought moves in three great spheres, namely: Nature, Man, God. It would be a profitable task to study the history of education with reference to the relative predominance of one or the other of these interests. The monastic schools of the Middle Ages laid their greatest stress on religious training. With the "revival of learning" came a period of humanistic studies. The 19th century brought a marvelous development of natural science and of mathematics. Nature study in its widest sense is beginning to receive a due amount of attention and our school curricula are becoming more harmonious.

The method of investigation in natural science work is inductive. The actual conditions under which natural phenomena take place are reproduced in the laboratories, and experiments are performed. These must be repeated a sufficient number of times to warrant the derivation and enunciation of a law. Thus, every laboratory experiment is a question addressed to nature, and the result of the experiment is nature's answer. When the investigation is of a *quantitative* character, results are expressed *numerically*. In the simplest cases the experiment involves one *independent* and one *dependent* variable. The problem is to find a constant relation between them. Two sets of figures are finally obtained. One represents the successive values of the independent variable; the other, of the dependent variable. Now, it is evidently the desire of every investigator to communicate his results to others in the most lucid and compact form. The numerical or statistical method alone, it was found, did not accomplish this. Who has not heard of dry statistics? The solution was eventually discovered in the drawing of diagrams or graphs, usually in accordance with a system perfected nearly three centuries ago by a French mathematician and philosopher.

This is another instance of the practical utilization of a tool devised at first for purely theoretical purposes. When Descartes, in 1637, published his Geometry, he probably did not realize the possibilities of his system. His genius presided at the marriage ceremonies of algebra and geometry, producing a union

(*The following paper was read at the December, 1905, meeting of the New York State Science Teachers Association before the mathematical section. It is printed here by request.)

that was to revolutionize science. Lagrange, in his fifth lecture on elementary mathematics, says: "As long as algebra and geometry traveled separate paths their advance was slow and their applications limited. But when these two sciences joined company, they drew from each other fresh vitality, and thenceforward marched on at a rapid pace toward perfection. It is to Descartes that we owe the application of algebra to geometry, —an application which has furnished the key to the greatest discoveries in all branches of mathematics."

The fundamental idea of the graph as usually drawn is so simple that a child can comprehend it. If two lines (axes) intersect at right angles, any point in the plane determined by the lines can be located if we know its distances and directions from the lines. With the usual convention of signs, two numbers are necessary and sufficient to fix a point in this plane. An infinite number of points can be so "plotted." If the points be determined in accordance with some definite law, a configuration of points of definite geometric form is obtained. If the law is expressed algebraically, this configuration is a picture or graph of the algebraic form or function. A graph, then, is really a pictorial representation, a condensed record, of related sets of numerical facts. One set of facts is represented on one axis (the horizontal); the second, on the other axis (the vertical). Points between the axes will show precisely which facts are related. If, for instance, equal divisions are laid off on the horizontal axis to represent units of time, and equal divisions on the vertical axis represent units of temperature, any point in the plane of the axes will show that at a certain time there prevailed a certain temperature. The line joining a number of these points for consecutive units of time gives a record of the temperature during the interval of time considered—it is the thermograph for that period of time.

Frequently, several sets of facts are closely related. It may be important, for instance, to know what influence the price of food has on wages, how tariff affects wages, and how agricultural prosperity reacts on the amount of exports and imports, etc. It is only necessary to draw, on the same axes, the graphs of the wages, the food prices, the tariff rates, of the harvest results, for the same period of time, to derive valuable conclusions as to the interrelation of these facts.

Evidently the range of application of the graphic method is

as wide as that of dependent phenomena, i. e., it is inexhaustible. This gives to the graphic method a great educational value. A recent writer says that the present mathematical renaissance has "a triune watchword—graphics, correlation, laboratory." Whatever criticism may have been directed against correlation and laboratory methods in mathematics, graphic methods are now endorsed by all progressive teachers. An algebra text is incomplete without them.

When and how shall this graphic work be introduced into elementary algebra? Graphs can be used to advantage at almost any stage of the high school curriculum, and therefore graphic work should begin as early as possible during the first year of the high school course. No special preparation for it on the part of the pupil is required. But before the specifically algebraic applications of the graph are taken up, the learner should be given a certain amount of introductory work impressing upon him the value and beauty of this method. I have found the following *sequence* of topics convenient.

I. Weather data (thermograph, barograph, etc.).
II. Science data.
III. Statistical data, relating to
  1. Population (increase, nationality, etc.);
  2. Natural products (agriculture, mining);
  3. Municipal, state and federal administration (taxation, postal service);
  4. Exports and imports;
  5. Industries (amount of manufactures, scale of prices);
  6. Commerce, interest, stocks and bonds, insurance;
  7. Economics (wages, strikes, prices of food, hours of labor, etc.);
  8. Hygienic conditions (mortality, diseases);
  9. Religious and educational conditions (school and church attendance, cost of maintaining schools and churches, etc.).
IV. Geometric applications.
V. Algebraic applications.
  1. Solution of simple problems (preferably motion problems);
  2. Simple functions $(ax+b)$;
  3. Linear equations $(ax + by = c)$; Rule of intercepts and quadrants;
  4. Simultaneous linear equations;
  5. Simple quadratic functions (x^2);
  6. Simultaneous quadratic equations (circle, ellipse, parabola, hyperbola.).

No one class should attempt all the preliminary topics. A few words of explanation may be necessary. I believe that the thermograph constitutes the easiest approach to the subject. The predecessors of Descartes plotted figures by rectangular coördinates called latitudes and longitudes. I would follow their example only to the extent of keeping the work, at the beginning of the course, in the first quadrant. Accurate weather data may

be obtained from any weather bureau. The official report blanks contain the hourly readings and the averages for the days and months. After an introductory lesson explaining the meaning and use of squared paper, the pupils bring a "daily thermograph." Then follow thermographs of the daily averages of *one* month, and of the averages of the *same* month during the last twenty years. (For a description of similar work see School Science and Mathematics, May, 1905.)

Science data, developed in the laboratories of the school, will be gladly furnished by the science teachers. Simple experiments, such as the weighing of pieces of crayon, might be performed before the class.

The statistical work may be based on newspaper and almanac records, on the reports of the various government bureaus, etc. Valuable information is contained in the bulletins of the Census Bureau, or of the Department of Commerce and Labor. The class should be shown some representative diagrams, and should then be permitted to plot any data of special interest to them. Sometimes graphs of startling originality result. The pupils enjoy this work.

A simple transition from the first to the other quadrants is furnished by the geometric applications. The law of signs is readily comprehended. Geometric figures are plotted from the coördinates of their vertices. The more important area formulas are deduced. How far this work may be carried, even in the grades, Mr. Campbell has shown in his admirable book on observational geometry.

Motion problems furnish the best preparation for the algebraic work proper. The latter is presented so ably in the recent texts and in a number of monographs, that it would be a waste of time to consider it here.

Graph work need not consume much time. After one or two lessons, a few minutes at a time will be found sufficient. The *main thing is that the graph become real to the pupil.* Every genuine graph tells a story. Professor Perry, in this connection, writes: "I was once sitting on a committee when a manager was detailing reasons why attendance at certain classes was steadily dropping. In idleness I manufactured some squared paper, quite roughly, and plotted the numbers, and it became at once evident that some curious event had happened at a particular date which had produced the mischief. This led at once

to the rectification of the evil. Now I do not say that a man clever at figures would not have discovered this from the figures themselves, but the importance of the squared-paper method of working is that no worry over details of figures distracts one from the general story told by them."

If it be necessary at all to furnish reasons for the introduction of the graphic method, I should give these:

(1) The graphic method brings the sum total of a set of related facts before us in a concrete, compact form.

(2) The study of a graph may lead to the discovery of the law governing the facts which it represents.

(3) The graph furnishes an easy mode of interpolating.

(4) In the school, the graph represents the simplest means of correlating the mathematical and physical sciences, and of introducing the activities of genuine laboratory work.

(5) It enables the student to test, at an earlier period, geometrical truths, and familiarizes him with the use of instruments and with units of measure;

(6) It gives him a new tool for the solution of certain problems;

(7) It makes him a more intelligent and interested observer of social, commercial and economic phenomena;

(8) Last, not least, it makes the study of equations, individual and simultaneous, of the number-system of algebra, intensely real, and affords a pleasant relief from the usual routine of that subject.

Let us rejoice, then, that the graph has at last come into elementary algebra. It has come to stay.

(The paper was fully illustrated by blackboard diagrams, printed charts and samples of work done by pupils. The following references may be of service:

(1) The recent text-books.

(2) Graphic Algebra for Secondary Schools, by H. B. Newson. Ginn & Co. 10c.

(3) Practical Mathematics, by Professor Perry. Eyre & Spottiswoode, London.

(4) Discussion on the Teaching of Mathematics. British Association, 1902. Macmillan.

(5) Especially, Report of the Committee on Correlation of Mathematics and Physics in Secondary Schools, of the Central Association of Science and Mathematics Teachers. Price, 25c. Apply to C. W. D. Parsons, 320 Main Street, Evanston, Ill.

(6) Graphs, by Robert J. Aley. Heath & Co. 10c.

(7) See also School Mathematics, March, 1904, and June, 1906.

CHEMICAL THEORY IN THE HIGH SCHOOL COURSE.

By Roy Fryer,

Of the Sacramento High School.

Chemical instruction in the high school is given for two quite distinct classes of students—those who expect to pursue the study further in the university or elsewhere, and a large number whose chemical instruction ends with the high school. So secondary instruction should be a foundation upon which further work can be based for the benefit of the first class, and yet it should be complete in itself for the benefit of the second class.

In preparing such a course we might give one which would fit the student for advanced work. We could introduce many topics which would be in touch with his future study or we might omit certain facts, knowing that he would become acquainted with them later. But such a course might be ill adapted to the needs of the other class who would have no chance to develop and complete these different lines of thought or find at a future time important facts omitted from the course. For these reasons it is our duty to lay special stress upon those parts of any subject which can be of use to the pupil whose work ends with the high school. I believe that the primary thought of a course in chemistry should be to find and make prominent those parts which best prepare him for life.

If it is given with this end in view it will not impair its value as a preparation for further work. On the contrary it will fit him equally as well and at the same time create in him a respect and admiration for a science which he finds is not wholly speculation but has a practical application in every department of life. Knowing this to be true, he will be in a better spirit to appreciate the principles upon which the science of chemistry is founded and to go on in a study of them when his mind is more mature and difficult conceptions are more easily grasped.

The advantages to be gained from a study of chemistry are generally given as two in number. First, it trains observation in general and teaches one to draw correct inductions from observations made. Second, it gives us much useful information about the natural components of the universe and the principles of manufacture and properties of artificial products.

According to the belief now held by our leading modern educators the first advantage can not be given the importance it once

held. Its value does not consist in promoting observation in general, or in a general mind-training. This value is limited to the observations and mind-training directly concerned with the subject of chemistry. One might in all probability be unable to tell the color of the house he lived in, because he had never observed it and yet have been taught carefully to observe the color in all precipitates formed in the laboratory.

Consequently the most important advantages we gain from the study of chemistry follow from the practical applications which we can make from it. It is believed more and more that the best material for a high school curriculum is that which appeals to the pupil as being worth while and which is taken by him because it is worth while.

So we see changes going on in all departments of education but especially so in scientific instruction. Biology has been gradually changed so that now instead of studying a mass of dry facts we endeavor to show that it is really a study of life. Manual training is being added to our grammar and secondary schools because its value consists in giving the pupil something which can be utilized, and interests especially those who will not have the chance to get beyond this elementary work.

I quote the following from an article written by Dr. Jordan entitled, "The High School of the Twentieth Century:" "The high school should not be primarily a preparatory school. It should work out its own problems in its own way. It is easier for the college to adapt itself to the high school, than for the high school to fit itself to the traditions of the college. When these traditions are founded on reason, the high school will naturally consider the matter on its merits. Where the requirements of the college are founded on tradition the easiest way to break with tradition is to ignore it."

We are bound down more or less in all our school work by this tradition of which Dr. Jordan speaks, and if we find that it applies to our teaching of chemistry it is our duty to find wherein it lies and proceed in the proper way to remove it. It is not the function of the university to lay down fixed rules governing the work of the secondary schools, for only a small percentage ever reach the university, neither is it the function of the secondary schools solely, but each should coöperate with and aid the other in making any necessary changes.

I have stated that while the course should be one which may

serve as a college preparation, our first purpose is to make it in the highest degree useful to those who do not take it for this purpose.

I have also stated that its value as a disciplinary subject is not nearly as important as its practical value.

Now which side of chemistry is best to serve this purpose or give it this value? If we speak of chemistry as being descriptive or theoretical, I think there is no hesitation in saying that the descriptive best answers our purpose; not a popular superficial course but descriptive chemistry as fully developed by laboratory and recitation work. Logically also the descriptive should precede any extensive theoretical work.

Theory can not be excluded altogether but it should play a subordinate part. The atomic theory would mean nothing to a person who knows nothing of chemical facts and it means little to one who knows little of these facts. Professor Agassiz has said: "One can see no further into a generalization than just so far as one's previous acquaintance with particulars enables him to take it in." Theoretical topics should be taught only as they are necessary for the correlation and explanation of experimental facts arising from the descriptive part. One year of chemistry can not make a chemist and facts of importance to a chemist only should be omitted.

Our problem is to find the minimum amount of theory necessary for the coördination of the descriptive part of chemistry.

Under the term, "Theoretical Chemistry," we include certain laws and facts which are well established and certain theories which explain these laws and facts, but which can not themselves be proven.

The most important laws and facts usually included in elementary chemistry are: (1) the belief in the existence of about eighty well recognized substances termed elements from which all other substances are made; (2) the law of conservation of matter; (3) the law of definite proportions; (4) the law of multiple proportions; (5) the law of combination of gases by volume; (6) the law of Charles; (7) the law of Boyle; (8) the periodic law. Besides these there are a few less important and some miscellaneous facts upon which it is needless to dwell as they will naturally fall into their proper place in the course.

The principal theories which we deal with are: The atomic and molecular theories and along with them Avogadro's hypoth-

esis; and the theory of ionization or electrolytic dissociation.

We will now consider each of these briefly as to its importance and place in the course.

It is unnecessary to spend time in a discussion of the elements for we recognize them as fundamental and probably all favor an early discussion of them in a general way with a fuller discussion of the important ones later.

The law of conservation of mass, being a fundamental one and easily comprehended, may be given at the very beginning of the course. It is not so easily proven at this time, but a direct proof is not necessary, for chemical work is full of its applications. Every reaction illustrates it so that it is forcibly impressed upon the pupil in a very short time.

The law of Definite Proportions on account of its importance should come early. There are many simple experiments which serve to illustrate it. I think that but little quantitative work should be given, leaving that for the advanced student. In the development of the subject the qualitative should precede it, yet here we may depart from this order. The best experiment for this purpose is the simplest, involving only direct combinations; such an experiment as that of determining the amount of oxygen which combines with a given weight of magnesium when it is heated.

The law of Definite Proportions should be followed by the law of Multiple Proportions. This being a more difficult fact to illustrate experimentally, that part may be omitted. However there is no special difficulty met with in its explanation after the law of Definite Proportions is understood.

The law of combination of gases by volume is not so important as those of definite or multiple proportions, and there will not be so many opportunities for its application. It could naturally follow some such experiment as that of the electrolysis of water.

(To be Continued.)

PROBLEM DEPARTMENT.

PROFESSOR IRA M. DELONG.

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Solutions and problems will be duly credited to the author. Address all communications to Ira M. DeLong, Boulder, Colo.

ALGEBRA.

27. ***Proposed by Eliza Robinson, Duluth, Minn.***

Two men start from opposite sides of a lake to row directly across. Their rates of rowing are uniform but not necessarily the same. They meet 720 rods from the left hand shore and each rows to the starting point of the other, rests ten minutes, and rows back again. This time they meet 440 rods from the right hand shore. Find the distance across the lake.

I. Solution by T. M. Blakslee, Ph.D., Ames, Ia.

Let distance be x, also A on right shore have rate a, B on left have rate b. Since A's and B's times are equal, first from starting to first meeting, second, between meetings,

$$\frac{720}{b}=\frac{x-720}{a},\ \therefore\ x=720\,\frac{a+b}{b}\ldots\ldots\ldots\ldots\ldots\ldots(1).$$

$$\frac{x-720}{b}+10+\frac{440}{b}=\frac{720}{a}+10+\frac{x-440}{a},\ \therefore\ x=280\,\frac{a+b}{a-b}\ \ldots\ldots(2).$$

(1) and (2) give $\frac{b}{a-b}=\frac{18}{7}\cdot\therefore\frac{a+b}{a-b}=\frac{43}{7}\cdot$ This in (2) gives $x=1720$

II. Solution by H. C. Whitaker, Ph.D., Philadelphia, Pa.

Let x denote the width of the lake, a the distance from the left shore when they first meet, b their distance from the right shore when they meet the second time. Then one man goes a while the other goes $x-a$; and the first goes $x-a+b$ while the other goes $x+a-b$. Therefore $a : x-a = x-a+b : x+a-b$ from which $x=3a-b=1720$ rods.

Also solved by J. Alexander Clarke, I. L. Winckler, H. J. Broderson, F. Zipf, E. L. Brown.

28. ***Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.***

A is one mile north of a certain point, B is one mile west. A travels due southeast and B travels east, both starting at the same time and moving at the same rate. How near will they approach each other?

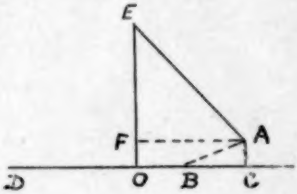
Solution by I. L. Winckler, Cleveland, O.

Let O be the given point, OD = OE = 1 mi., and DB = AE = x.

Then OB $= x-1$ and AF $= \dfrac{x\sqrt{2}}{2}$

$$BC = AF - OB = \frac{x\sqrt{2}}{2} - x + 1$$

$$AC = OF = 1 - \frac{x\sqrt{2}}{2}$$



$$\overline{AB}^2 = \overline{AC}^2 + \overline{BC}^2 = \left(\frac{x\sqrt{2}}{2} - x + 1\right)^2$$

$$+\left(1 - \frac{x\sqrt{2}}{2}\right)^2 = (2-\sqrt{2})\, x^2 - 2x + 2$$

$$= (2-\sqrt{2})\left[\left(x - \frac{2+\sqrt{2}}{2}\right)^2 + \tfrac{1}{2}\right]$$

Hence the least value of $\overline{AB}^2$ is when $x = \frac{2+\sqrt{2}}{2}$ and $\overline{AB}^2 = \frac{2-\sqrt{2}}{2}$

Theretore the least distance apart of A and B is

$$\sqrt{\frac{2-\sqrt{2}}{2}} = .541 \text{ miles.}$$

Also solved by F. Zipf and the proposer.

GEOMETRY.

29. *Proposed by I. L. Winckler, Cleveland, O.*

Show how to bisect the area of any quadrilateral by a line passing through a given point in one of its sides.

Solution by J. Alexander Clarke, Philadelphia, Pa.

Let ABCD be the quadrilateral, M the given point in the side BC. Draw diagonals AC and BD; take O as the mid point of AC, draw BO, DO; also OE parallel to BD, meeting AD in E. Join ME and draw BF parallel to ME, meeting AD in F. MF is the required line.

Obviously, triangles BCD +BOD = ½ABCD. Triangle BDO = triangle BDE, and therefore triangles BCD + BDE, = ½ABCD, or, MCDE + triangle MEB = ½ABCD. But triangle MEB = MEF (same base ME and equal altitudes); and therefore, MCDE + MEF =MCDF = ½ABCD.

Also solved by I. L. Winckler, H. C. Whitaker, F. Zipf, E. L. Brown.

30. *Proposed by P. G. Agnew, Washington, D. C.*

A frustum of a cone has its radii R and r and its altitude h. Where will a plane parallel to the bases cut off $\frac{1}{n}$th of its volume?

Solution by H. C. Whitaker, Ph.D., Philadelphia, Pa.

Let $h + a$ be the altitude of the completed cone, $a + x$ the altitude from the vertex to the required cut. Evidently $a = \frac{hr}{R-r}$ Then

Vol. cut off : original vol. $= a^3 : (a + h)^3$

Take this by division

Vol. cut off : vol. given frustum $= a^3 : (a + h)^3 - a^3$

Similarly using cone to required cut

Vol. cut off : vol. required frustum $= a^3 : (a + x)^3 - a^3$

The quotient of these two proportions gives

$$\frac{(a+x)^3-a^3}{(a+h)^3-a^3}=\frac{1}{n}.$$ Whence

$$x=\sqrt[3]{\frac{(a+h)^3+(n-1)\,a^3}{n}}-a$$

Substituting the value of a gives

$$x=\frac{h}{R-r}\left[\sqrt[3]{\frac{R^3+(n-1)\,r^3}{n}}-r\right].$$

Also solved by J. L. Riley, I. L. Winckler, F. Zipf.

A solution of Problem 23 was received from O. R. Sheldon too late for crediting in the October issue.

TRIGONOMETRY.

31. *Proposed by E. L. Brown, M.A., Denver, Colo.*

In a triangle $\frac{\sin A}{\sin B}=\frac{m}{n}$, and $\frac{\cos A}{\cos B}=\frac{p}{q}$.

Show that $\cos C=\frac{mp-np}{np-mq}$

Solution by J. M. Kinney, Spencer, Ind.

By multiplication $\frac{mp}{nq}=\frac{\sin A}{\sin B}\frac{\cos A}{\cos B}=\frac{\sin 2A}{\sin 2B}$, and therefore, by composition $\frac{mp-nq}{nq}=\frac{\sin 2A-\sin 2B}{\sin 2B}=\frac{\cos(A+B)\sin(A-B)}{\sin B\cos B}$ ....(1).

By division $\frac{mq}{np}=\frac{\sin A\cos B}{\sin B\cos A}$, whence $\frac{mq-np}{np}=\frac{\sin(A-B)}{\sin B\cos A}$ .....(2).

Dividing (1) by (2) we have $\frac{\cos(A+B)\cos A}{\cos B}=\frac{mp-nq}{mq-nq}\cdot\frac{p}{q}$, or

$\cos(A+B)=\frac{mp-nq}{mq-np}$, and since $\cos(A+B)=-\cos C$, $\cos C=\frac{mp-nq}{np-mq}$.

Also solved by T. M. Blakslee, H. C. Whitaker, I. L. Winckler, F. Zipf, O. R. Sheldon and proposer.

PROBLEMS FOR SOLUTION.

ALGEBRA.

36. *Proposed by P. G. Agnew, Washington, D. C.*

Coal is on the deck and coal is running on the deck from a chute at a uniform rate. Six men can clear the deck in an hour, eleven men can clear it in twenty minutes. How long will it take four men to clear the deck?

37. *Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

A man can go to a place by two routes. The shorter route can be made by rail in 6 hours, by boat in 20 hours, and on horseback in 30 hours. In going he takes the shorter route and travels an equal number

of hours by each conveyance. He came back the longer route and traveled as many miles horseback as he had traveled by rail in going, as many miles by rail as he went horseback in going, and as many miles by steamer as by both rail and horseback. What was the total time consumed in traveling and what is the ratio of the lengths of the two routes?

GEOMETRY.

38. *Proposed by L. M. Saxton, Edgewater, N. Y.*

Given ABCD as any parallelogram, E any point in AB, F any point in DC. Join E with D and C, and F with A and B. Let AF meet DE in Y, and BF meet CE in Z. Let the line YZ produced meet AD in P and BC in Q. Prove that PQ divides ABCD into two equivalent parts.

MISCELLANEOUS.

39. If sin A, sin B, sin C are in harmonical progression, so also will be 1—cos A, 1—cos B, 1—cos C; $A+B+C=180°$.

Suggestions to Problem Solvers.

1. Write legibly, being specially particular as to proper names.

2. Write on one side of the paper only, reserving at the top and the left a two-inch margin for the use of the editor.

3. It is very desirable that each problem be given a separate sheet; also, a separate sheet for any communication not intended for publication.

4. In any algebraic solution, or system of equations, only those should be numbered to which subsequent references are made.

5. The simpler geometrical solutions should be so worded that they may be readily understood without the aid of a diagram. If a diagram cannot well be omitted, it should be furnished to the editor in duplicate, one copy on the sheet with the solution, and another copy on a separate sheet, done accurately in ink so that it may be photographed.

6. All solutions should be in the following standard form:

   (a) The subject heading (Algebra, Geometry, Trigonometry).

   (b) The serial number of the problems in Hindoo figures.

   (c) The name, academic degrees, and postoffice address of the contributor.

   (d) The body of the solution.

A NEW MOVEMENT AMONG PHYSICS TEACHERS.

CIRCULAR III.

Notwithstanding the fact that the answers to the questions in Circular II were asked for during the summer vacation, when a teacher wishes to be rid of all thoughts of teaching, 130 answers were received. These came from 83 high schools, 9 normal schools, and 38 colleges. The geographical distribution of those who answered is very similar to that published in the last circular, nearly every state in the Union being represented.

The tabulated summary of the answers received is as follows, the numbers in parentheses indicate the number of votes in each case:

Question 1. The replies to this question concerning the best methods of keeping notebooks were generally very full, showing that a large amount of attention is being given to this important matter by the teachers.

Many believe that the student should not be asked to make out his own form of report (9), but should record his results in printed tabular forms (25). On the other hand, others think that the printed forms should not be used (35), but that the student should be required to work out his own form, after a few weeks of drill and experience under the guidance of the instructor (60). It is suggested that if the student is encouraged to describe his work in his own way—so that he feels that he is bookmaking rather than bookkeeping—he will take pride in his work (8), and he will record only work that is distinctively his own (9). In any case, the report must be concise (12) well systematized (11), contain no descriptions of apparatus (9), no drawing (9), no details of the method of performing the experiment (5), and no copying from the manual (5).

The time of the teacher may be saved by having the student hand in his results immediately and having them inspected during the laboratory period (24); in which case a loose-leaf manual or notebook, with drawing of the apparatus but not much description of the experiment, is desirable (22). Time may also be saved by using the graph for tabulation of data (6), by so coördinating the experiments that the result of one checks that of another (2), by not requiring the student to attempt to write a description of things he does not understand (3), and by letting the student give oral explanations instead of written ones, the data and conclusions only being recorded (3). Three suggest that only one out of six experiments be written up in full, the rest being reported on tabular printed forms.

As to the minimum requirement, four vote for 40 experiments, five for 30, and ten for 20, it being understood that these are all quantitative. Six urge that no notebooks be required by the colleges for entrance, but that the certificate of the school be sufficient. The minimum record for a report of an experiment should contain: 1. Purpose (34); 2. List of apparatus (12); 3. Drawing or diagram (21); 4. Description of the method of work (27); 5. Tabulated data or results of measurements (33); 6. Discussion of data and conclusions

(35); 7. Discussion of errors (5); 8. Answers to questions by the instructor (2); 9. Historical notes (1); and 10. Meaning of experiment to student (2).

Question 2. Every one of the answers to this question stated that the amount of subject matter usually compressed into the one-year course is too great. The methods of reducing it may be summarized as follows:

By omitting either the parts that are largely mathematical (21); or the more abstract parts (17), or the less essential parts (20); or one whole division of the subject (13). We might also cut out descriptions of antiquated apparatus (3), fads (4), special rules (5), work belonging properly to the college (4) or to the technical school (5). We should introduce only the simplest and most necessary units (3); omitting the dyne, the erg, the poundal, etc. (7). We might also omit the parts that are not easily understood (7), suppress all unnecessary detail from the text-books (3), and reduce the discussion of mechanics to half the space usually given it (2).

Simplification might also be obtained by a better organization of the subject matter (7); for example, by making the idea of energy the center and grouping the other material about this (4), or by intensifying the parts that are immediately connected with the student's life (7). The facts and laws studied should be limited to fundamentals —no physics curios—(6), or to facts which clearly relate to the life of the students rather than to the laboratory (5). There should be more laboratory work on fewer principles (2), more study of phenomena first (15), and no principles should be given till the phenomena which they resume are clearly grasped (5). We should also evaluate the work less by the amount of ground covered and more by its quality (3). It might also be well to conduct the course by assigning no lessons from the text, but rather giving a series of problems that necessitated for their solution a study of the text (2). A course might be devised consisting simply of forty typical experiments with questions and problems on the practical application of the principles involved (2). Others think that the reduction should be different in each school, being left entirely to the teacher (3).

Some claim that the method of presentation is vastly more important than the choice of subject matter, so that a few things well presented are of more value than a large number poorly done (7), while others claim that it is important to give a general survey of the whole field, even though parts of it are not appreciated at the time (2).

Question 3. Of those who answered this question, 47 prefer to have physics in the fourth year, 25 want it kept in the third year, and 12 want it in both. Fourteen suggest that there should be a simple descriptive course in the first year, to be followed by the present course in the fourth.

Question 4. The vote on the question as to how much of the time should be spent in laboratory work was as follows: one-fifth (5), one-third (28), two-fifths (28), one-half (33).

Question 5. This question brought out many valuable suggestions

as to what the associations might do to help the teacher in perfecting his work. Some of these are as follows:

The associations should organize a campaign for the education of the public, the superintendents, the principals, and other school authorities concerning the conditions necessary for efficient work in physics, namely, the teacher must have a free period immediately before a demonstration lecture (17); also time to prepare for the laboratory work (18); also, because of the time required for the satisfactory care of the apparatus, he should have one hour a day less teaching than those who do not have to work with apparatus (29). Statistics should be gathered as to the weekly hours of work by physics teachers and by others (28), and also concerning the apparatus and equipment of the schools where satisfactory work is done (3). Membership in an association should give a teacher rank and standing (9), so that people recognize that he is not the mechanician, carpenter, janitor, and scrub-lady combined (2). Through the associations the teachers should also control the ways of entering the profession, as is done in medicine, law, theology, etc. (4). One suggests, "Why not have a Union?" The associations could also help in insisting on double periods for laboratory work (4), and in securing more time for the subject in the curriculum (2). They might also unite in the production of a satisfactory text (1), and in helping the teacher to free himself from set forms and syllabi (7).

The colleges might also be reached by the associations and persuaded to accept for entrance the work done by the high schools as the high school teachers see fit to do it (19), and to lay more stress on the quality of the work rather than on its quantity (8)—perhaps they might be seduced into accepting twenty topics well understood in place of forty experiments as the sine qua non of entrance (5).

The associations could assist the teacher by publishing a teachers' manual (8), by issuing circulars telling how experiments may best be done (3) and by keeping up the present agitation (10).

Question 6. Many possible forms of syllabus were suggested in answer to this. Although two think the syllabus a delusion and a snare, most believe that one might be framed that would help rather than hinder the teacher. Here are the suggestions:

The syllabus should consist of a number of fundamental principles, together with a requirement of the comprehension of a certain minimum number of them and a long list under each of means and methods of teaching that principle, and then leave the teacher free to select both the principles he will teach and the means of doing it (26). It should be intensive in each subject and require only sixty per cent of it (3). The syllabus must contain a much larger number of experiments than required for a year's work, and leave the teacher free to select (22). Such a list of experiments should be accompanied by an obligatory minimum requirement (4), but it must be flexible (15), and allow substitutions (10). It might outline the essential parts, giving references, and let the teacher fill in (5).

Instead of a syllabus, it might be better to approve a score of textbooks, and trust the teacher for the rest (3); or, we might simply

draw up a comprehensive and varied list of questions for the pupil to be able to answer (3). Only about half of those who replied attempted to answer this question.

Question 7. The purpose of instruction in physics is a matter on which there is wide diversity of opinion, as may be seen from the following summary of the replies:

Physics instruction should bring the student into intelligent touch with the world of natural phenomena about him (30), give him some comprehension of the working of practical and familiar things (17), increase his knowledge of fundamental facts (14), teach him the fundamental laws of physics (18), rationalize his knowledge of phenomena (7), show him that Nature works by law (10), reveal to him the vast extent of the unknown (2), and bring him to appreciate the limitations of experimental accuracy—man's handicap (2).

Such instruction should also develop reasoning power (26), logical thinking (2), ability to detect and use laws (9), interest in the applications of laws (6)—powers of close observation (15), of interpreting observations (15), of solving problems for himself (6), and powers of doing things and of taking the initiative (5). It should also foster the scientific method of thought (14), arouse the imagination (2) and the love for beauty and truth (3); should develop accuracy in measurement (6), computation (5), and expression (4). It should show him the value of accuracy (2) and of quantitative knowledge (2), and the desirability of testing things by measurement (3). One suggests that the first six or seven months' study should be purely informational, and the rest review, since reasoning begins later. Two others lay stress on showing the student that scientific knowledge increases our power over things by enabling us to predict what will happen under a given set of conditions. Finally, two think the purpose of the physics course is to teach physics.

The most important suggestion as to method of testing whether the aim of the course has been attained in this, that the teacher observe his pupils and study their work (18), and then judge his acquirements by his interest in physics problems outside the laboratory (6), and his power of solving simple original problems (7). It is suggested that there should be frequent short tests (10), careful inspection of the notebook (9), and a final examination (5) which is framed to test power of thought rather than memory (4). One suggests that a committee of the associations should frame the examination questions, which should concern themselves with broad general principles only. Three others call for no final examinations, but suggest quizzes on practical subjects. Five want the colleges to accept the certificate of the school without special examination by the college. Five others suggest as a suitable form of examination the requirement of the description of a new machine or piece of apparatus.

Question 8. The following suggestions as to what associations could do to encourage teachers to take membership in them were submitted:

The program should be made up of interesting papers with discussions (10); the subjects treated should be concrete problems met with

in actual work (8), not academic discussions (3), nor yet long winded papers supposed to be instructive (5); but more heart-to-heart talks in which the teachers are not lectured to but engaged in conversation (3). To encourage attendance the meetings should be held at other times than Thanksgiving and Christmas (2), and the schools should pay the expenses of the teacher, besides giving him the necessary time off (5), or else pay better salaries so he could afford to go (10).

Interest should be kept up between meetings by printing and distributing bulletins of practical import (15), or by a running discussion by means of circulars like these (17). The transactions should be printed in full (5), and the association should be so administered that the teacher could not afford to miss it (7). All members should be put to work, so that each feels that the association needs him (18), and local centers should be formed for more frequent meetings (6). The general meetings should be held in different parts of the state each year (5), and the offices should be passed around (5). Visits to manufacturing plants (3) and apparatus exhibits (5) add to the interest.

The meetings should be less formal (2) and the social element should be prominent (7). Attendance on meetings should be required by the schools (3) or the teacher asked to resign (2). All should take the teachers' journal and read it thoroughly (6).

To anyone who has read the summaries of these answers, together with those printed in Circular II, it must be very evident that physics teachers are far from agreed as to the aims, methods, and needs of their work. Under these conditions it seems unwise to attempt to frame a detailed outline of a course until we can agree on some general propositions. Since work similar to this has been going on in both Germany and France for some time, it has been suggested that perhaps we can accept first some of the broader principles on which the German and French Associations have agreed as of fundamental importance. The theses proposed below are not literal translations of the German and French ones, but have been rewritten to meet American conditions as revealed by this discussion. The foreign theses may be found in the article by Young in *Science* for May 18, or more fully in the *Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht*, Vol. 35, page 359; Vol. 36, page 539; and in the *Conférences du Musée Pédagogique*, 1904.

1. The subject matter of the first-year course must be reduced to two-thirds its present amount, or else the time allowed for covering it increased to one and one-half years.

2. If the subject matter is reduced, the more abstract, mathematical, and technical topics, that is, those that have no possible bearing on the student's life, should be first eliminated. The better established portions of the subject should have precedence over the more recent unproved speculations, on the ground that in the limited time it is better to teach things which are likely to be still believed when the youngster is grown up.

3. In the first year course the method of presentation is of far greater importance than the choice of subject matter, *i. e.*, it is better

to present a few topics in such a manner that they are powerful examples of the method by which science obtains its results, than to try to teach a large number of more or less scattered facts and theories in such a way that they can only be committed to memory.

4. No definition should be introduced until the concepts with which it deals have been clearly developed in the student's mind by means of a discussion of concrete cases from the student's own world. In other words, a definition must be justified before it is stated, not after.

5. No law should be stated until the concepts and relations with which it deals have been implanted in the student's mind by means of a discussion of common experiences and of simple qualitative demonstrational experiments. After the concepts and the idea that there may be a quantitative relation among the factors involved have been grasped, the quantitative relation may be stated and proved either by demonstration or laboratory experiments. In other words, the student must be given an intuitive and qualitative perception of the relations summarized by the law before he is expected to comprehend and use it intelligently.

6. The student should be made to see clearly that laboratory apparatus furnishes the means of determining quantitatively the relations summarized by laws. He should also be made to see that the apparatus is not the law, and that it is not necessary to remember the details of the apparatus in order to appreciate the law, and that the exemplifications of the law are not confined to the apparatus.

7. The student should be made to comprehend that every law has been established by a method of approximation, so that the statement of the law is always a statement of what we believe to be true in an ideal case. Hence the measurements by which the law is established give results which approach more and more nearly to the law, the more carefully the measurements are made, and the more completely complicating effects are eliminated. He should also understand that in every practical case the law is not verified because of friction, air resistance, etc.

8. Measurements of the relations involved in practical cases lead to determinations of efficiencies rather than to the verification of laws. Such determinations of efficiency furnish for the laboratory work problems which are of great value and interest because of their reality.

9. As few units as possible should be employed, and they should be introduced only when a necessity for their use appears, *i. e.*, their introduction should be justified in advance as in the case of definitions. By this thesis the more abstract units like the dyne and the erg would be ruled out of the elementary work.

10. Examinations and quizzes should be framed to test the student's comprehension of and ability to use the more important principles of physics. The questions should not ask for mere statements of laws from memory; nor should they contain complicated arithmetical puzzles of the sort that never occur in practical work. They should not demand descriptions of laboratory apparatus, nor of unrelated facts which do not have any immediate bearing on the principle involved.

They should rather consist of questions as to the argument by which a principle is established, and as to how the principle is applied in daily life; also of simple problems, which deal with immediate concrete applications of the principle, and which are of the kind likely to be met outside of the class room or laboratory.

It is proposed to use these theses, or such others of like nature as the physics teachers may elect, as a preamble to the new syllabus. All who are interested in this work, and who wish to help it along, are invited to send approval, disapproval, criticisms, additions, or other suggestions concerning them to the committees. Such answers must be sent in promptly, as the new syllabus is now being drawn up. They should be in not later than November 15.

The theses in this circular have not yet been approved by the joint committees. They are being submitted to the members of those committees just as this is going to the press. Since these theses are important it was considered desirable to submit them to the committees and to the physics teachers simultaneously, in order to get as extensive an expression of opinion on them as is possible. Let us have your opinion of them, whether it be affirmative, negative, or both.

This circular is being sent, in consideration of the fact that the summer is not the time to work teachers, to all who have answered either of the others. The new proposed syllabus will be ready for distribution about December 1, and will be sent to all who take enough interest to answer this one or to signify their desire to receive it. All communications concerning this should be sent as before to C. R. Mann, Ryerson Laboratory, University of Chicago.

INCREASED POPULARITY OF COKE.

Aside from the extended use of by-product coke in blast furnaces and foundries, the employment of crushed and sized coke for domestic and industrial purposes as a substitute for anthracite and bituminous coal has increased notably. This is a point emphasized by Mr. Edward W. Parker, statistician of the United States Geological Survey, in his forthcoming report on the production of coke in 1905. The plant at Camden, N. J., has restricted its output for foundry purposes and now relies mainly upon the domestic trade in Camden, Philadelphia, and vicinity, which has been such as to justify an increase in oven capacity of over fifty per cent. The plant at Hamilton, O., has added to its equipment for crushing domestic coke, and a larger proportion of its output than ever before now goes to this field. Operators of the plant at Glassport, Pa., have also found that the demand for domestic coke was sufficient to justify the installation of improved crushing equipment. At Everett, Mass., practically the pioneer in the production of coke for domestic consumption, the coke product is now easily and regularly disposed of, being divided about equally between domestic or industrial uses and fuel for locomotives in suburban traffic. —*United States Geological Survey.*

LABORATORY TEACHING.*

President Chas. W. Eliot, Harvard University.

Your president has indicated the great change during the past twenty years in the position occupied by the subject of physics, and I may add chemistry and biology, in the secondary schools. Now the change there is no greater than that which has taken place in the colleges entirely within my remembrance. When I was a student in the Harvard College, there was not a single laboratory open to the students on any subject, either chemistry, physics, or biology. The only trace of such instruction open to students was in the department of botany, and that was only for a few weeks with a single teacher, the admirable botanist, Asa Gray, and he had neither apparatus nor assistants, and it was a hopeless job which he undertook for a few weeks in May and June. I was the first student who ever had the chance to work in the laboratory in Harvard College, and that was entirely due to the personal friendship of Prof. J. P. Cook, who fitted up a laboratory in the basement of University Hall, entirely at his own expense. That was the situation of the colleges in the country—for Harvard was by no means peculiar in this respect—only sixty years ago. There has come over American education a prodigious change in the teaching of science all within fifty years. The particular event which your president mentioned is one instance of the change in American education which we may all believe is going to be very far-reaching and very effectual.

One of the things that your teaching aims at, as you teach in the laboratories, is to train the powers of observation, and what may be called the judgment in inferring, the kind of judgment that is a guide to conduct in this world. The father of the present American ambassador in Berlin was born in central New York and his father was a prosperous farmer. Accordingly the father and the boy decided between them that he should be sent to Harvard College. This was in 1826. The way he got to Harvard was by riding a horse with a pair of saddlebags bound behind him, which contained his entire equipment. I have heard Mr. Tower, the father of the ambassador, say that it took him three weeks to come from his home to Cambridge in that method and that he had considerable difficulty in finding his way and his food. When he got to Cambridge he sold the horse at a profit. Now there was a training in that performance for the father of the ambassador that the ambassador never got, and which the ambassador missed, and has missed all his life. When he wanted to come to college from Philadelphia, he rode in an arm-chair all the way for ten hours, no training in that at all, but a great deal of training in what his father had to do to get to college. Now that is typical of what has happened all over our country with regard to the training of youth.

In the training of youth during the last fifty years, the memory side has been developed, the observation side has suffered terribly.

*Address before Eastern Association of Physics Teachers at the Harvard Union on February 10, 1906.

You are contending against that inevitable tendency of civilization and luxury. Of course, the civilized man is not driven to the cultivation of his sense powers in the keenest way, by hunger and cold, as the savage is. The savage's senses were trained, particularly among the men, to a very high degree by the necessities of hunting and finding his way in the forest, by fishing on the sea with very poor appliances, and in war. The civilized man lacks almost completely that development in keenness of observation which the savage has got. The laboratory training which you are trying to give to generation after generation of boys and girls supplements this defect in civilized life.

It, of course, accomplishes another more effective result by giving to a few who have remarkable powers of observation, a chance to cultivate those powers when young. When I was in Harvard College, the young men who subsequently turned out to be physicians were almost uniformly at the foot of their respective classes. That was an inevitable result of the fact that the whole discipline of the college was on the memory—in history and language. Of course a good training in language involves also a training in discrimination, in perceiving the differences of words and phrases, but the naturalist turn of mind had no chance at all in the college in my day, nor ever had had. Therefore the fellows who went into the medical school were almost exclusively drawn from the bottom of the class. A very striking illustration of it was Prof. Geoffrey Weymouth, who in college could do nothing that was set before him, a man of extraordinary gifts in naturalistic observation. He subsequently became one of the most eminent naturalists that our country has ever produced, but he was at the foot of his class in Harvard. That marks the great change which has taken place here. I know several physicians and surgeons now practicing in Boston and other cities who were at the head or near the head of their respective classes in college. Why? Because the college now and for the last twenty years has offered them a whole series of studies adapted to their faculties, intended to bring out their powers, so that they could succeed on the college rank lists.

There are then two quite distinct functions which school and college laboratories perform. They tend to raise the observational powers of the average, and they give a chance to men of remarkable capacities to develop these capacities. I suppose, however, that all of you have discovered that it is quite as possible to abuse this method of instruction as it is to abuse the use of the dictionary and grammar. By abuse I mean to use it in a wrong way which defeats the whole object of the training.

I had a letter yesterday from a professor now past the prime of life, in a remote university who, writing on another subject, mentioned at the end that he had always felt under obligations to a little book in the preparation of which I was concerned forty years ago—"Eliot and Storer's Manual of Chemistry"—and he said why it was that he had always felt under obligations to that book. It occurred to me that it was forty years ago Professor Storer and I worked on that book, and I recollect the way we worked on it. It was written out, of

course, in manuscript first; then it was put into proof, and those proofs we tried on the classes we were then teaching in the Institute of Technology, where from the very start, in 1865, the laboratory method was planted and assiduously cultivated. We had a variety of classes, because we offered instruction in that early day to teachers in several classes in the afternoon, both men and women, and we had classes running through the whole four years of the course of instruction at the Institute; and all through those classes we had an opportunity of trying these proof sheets. The difficulty we encountered was this—that almost every person into whose hands we put those proof sheets and asked to use them in the actual performance of experiments, wanted to regard the experiment as a means of verifying the statements in the manual, not for the purpose of seeing for themselves; having read what the phenomenon was, they were willing to try and produce this phenomenon as a means of verification. That was completely upsetting our purpose and we struggled with some success, far from perfect success, to prepare that book so as to make that particular use of it less natural or less inevitable. It was the only manual of that sort at that time in the English language, and it was some gratification to me a few years later to find that for that reason, because it was the only one in the English language, it got admission to some famous English schools where they were first trying to teach chemistry by the laboratory method, notably at Rugby. Now we have a perfect flood of experimental manuals in all the sciences, intended for use in elementary instruction, and I think that I discern in all of them, through all of them, that this same difficulty occurs, that the teacher must always struggle against that tendency of youth, the main part of whose time is given to memory studies, to regard the book, the statements of the manual, as an authority which he accepts but is willing to verify by inspection of the results of experiment. This use of manuals, experimental manuals, is a real defeat just as the ordinary use of a dictionary or a vocabulary by the careless student who looks out every time the meaning of a word when it occurs, as the quickest thing to do, defeats the real cultivation of the mind through the study of language.

There has arisen a social and industrial condition in our country, and indeed in all the civilized countries, during the last twenty-five years, which makes more important than ever, to my thinking, the kind of training which you offer to children. In the first place, looked at at one end of the industrial series, the independent power of inventive observation and imagination becomes more and more important to progress in all the arts and trades and industries. This depends, of course, on the leaders, on persons who have constructive imagination—for I am sure you have seen that although you work with your pupils with implements, things, and desire them to observe actual, real phenomena—the progress of science, like the progress of civilization, depends really upon the human imagination. At one end of the series, therefore, it is for us to train leaders and pioneers, the people who are capable, having brought themselves up to the limits of knowledge,

of peering a little way into the mists beyond. But there is another great function, and that is to train men by the million to the use of implements of precision. Of course all our industries and processes of transportation and distribution are now full of that use of implements of precision, of implements which have a delicate, exact, and accurate quality, and men and women need to be trained to the use of such implements. A wonderful change in this respect you have all witnessed, though most of you are young. It is not the soldiers only who have been inevitably and utterly changed in this respect. The soldier or the sailor has now got to be almost a mechanic, skilled in the use of implements of precision and the naturalist follows along to enable the soldier, the sailor, mechanic, and workmen, to use implements of precision.

I was very much struck the other day, in listening to the Chief Surgeon in Admiral Togo's fleet, who was present at the battle of the Straits of Japan, describing to the Admiral of the British fleet, Admiral Seymour, what he did in the way of enabling the sailors of that fleet first to fight, and then to bear with greater safety their wounds. The precaution about the fighting was this—in every place where guns were used, turret or gun-deck or whatever else guns were fired, he placed in great abundance cups of an eyewash containing boracic acid among other things. I saw Admiral Seymour smile the incredulous British smile, but the surgeon said the eyes of the men are very much affected by the smoke in those places, and it is of no use for a man to fire a gun nowadays unless he can see. Now there was the naturalist helping the mechanic to use an instrument of precision, and to use it with effect. These sailors were taught to swab their eyes out whenever they felt hurt by the dense smoke. But then the soldier and the sailor and the mechanic has got not only to be helped by the naturalist to avoid conditions which injure his efficiency—he has got to be himself efficient. Thus sailors must be able to sight a gun, to adjust it quickly and correctly to the distance of the objects aimed at, to use, in fact, the terrible instruments of precision which the mechanicians of the day put at the disposal of the soldier and sailor. Now there is still another difficulty in modern life against which the training you supply contends. Hundreds of thousands of men and women work under such circumstances that their intellectual and their manual labor becomes almost automatic, tends to become automatic. That, of course, is an injurious effect of many industries on the sense and the thinking power of operatives. When a man works in an automatic way from nine to ten hours a day, he needs very much some counteracting influence, some mode of using his mind which is independent of the machine which he has to keep up with, some independent use of his senses and his inferring power; and it is the exercise of just such powers as you train in children which will afford infinite relief to workers who in after life spend a large portion of each day in a process almost automatic.

There is another form of relief which I saw illustrated in a shoe-factory in Roxbury, a new one very intelligently laid out and con-

ducted. The proprietor had provided a very good gymnasium, but it was furnished with the usual apparatus of parallel bars, hanging ropes and rings, and the various apparatus one finds in a gymnasium. Rather too late, that is, after the gymnasium was equipped, he employed a superintendent for the gymnasium, and the first thing the superintendent did was to clear the floor as much as possible of this apparatus. He left the chest weights around the walls, but he got as much as possible of the apparatus out of the way, off the floor. I noticed this, and asked him why he had done it. He said, "When men and women have worked on piece work"—that is the most automatic work if the piece is small and unchanging—"nine hours a day, the exercise they want is free play, games, not class work on gymnasium apparatus." It seemed to me to be a very just observation and one that goes a good way beyond the circumstances under which that particular policy of his was put in force. There is a new argument for freedom, freedom a good part of the day for individual action, and not team play. Team play is inevitably mechanical, and the more automatic it is the better, that is, the better towards the end of victory, if that be an object. Now every bit of training that you give prepares your pupils in after life for the individual play of faculties out of doors and indoors, in freedom as individuals, and it is a very high service that you render and one that will tell all through their lives, if you can put into them the individual power to observe, judge, infer, record. Yours is not class work. It is individual work, and must always remain so if it is successful. I need not say that is the highest kind of teaching, and it is the kind of teaching which is being developed throughout the university of every grade. Take for instance, the medical school —the Harvard Medical School. There are in that school something over three hundred students. There are one hundred and forty teachers, every one of whom is an expert and every one of whom shows students, taken one at a time, just how he has got to use his eyes, ears, nose and fingers to make medical observations. That is your method of instruction, that is your way of service carried to a very high degree. It is almost a teacher to two students. I hope you will contend in every possible way in your respective schools for individual instruction, for the reduction of the number of pupils to one teacher. It is a barbarous condition where in Boston, for example, fifty-six pupils are put in charge of one young woman just out of the normal school. It is absolutely an impossible task for the teacher. Now all your work is helping the public school, the endowed school, the private school, out of that difficulty, which is the most serious difficulty with which American education now has to contend. All your work tends toward individual instruction.

This whole subject of laboratory teaching is one that interested me very much when I was young. I profited by the only chance there was in Harvard College when I was a student here sixteen years of age, and I have never forgotten my obligations. N. H. B.

PROPOSALS FOR REFORM IN THE TEACHING OF MATHEMATICS AND SCIENCE IN THE NINE-CLASS HIGHER SCHOOLS OF PRUSSIA.*

H. E. COBB, *Lewis Institute, Chicago.*

At the annual meeting of the *Gesellschaft Deutscher Naturforscher und Aerzte* in Breslau in 1904, after a long discussion on the teaching of mathematics and science a commission was appointed to consider the question further and formulate some propositions for reform. At the first meeting of this commission in Berlin, December, 1904, a mathematics-physics and a chemistry-biology subcommission, were appointed. The report of this commission consists of a general statement of its work, followed by detailed reports of the subcommissions—(1) on the teaching of mathematics, (2) on the teaching of physics, and (3) on the teaching of chemistry together with mineralogy, and zoology together with anthropology, botany and geology.

The commission agreed upon the following general propositions:

"1. The commission desires that in the higher schools there should be given neither a one sided language-history nor a one sided mathematics-physics training.

"2. The commission recognizes that mathematics and science are of as much value as means of instruction as are the languages, and holds fast to the principle of general culture in the higher schools.

"3. The commission declares that it was absolutely necessary that the higher schools (Gymnasien, Realgymnasien and Oberrealschulen) should have equal rights and privileges and desires that this may be fully accomplished."

(On November 26, 1900, a decree of the Emperor was issued which declared that the education imparted in the Gymnasien, Realgymnasien and Oberrealschulen was to be considered of equal value. Until this date the leaving certificate of the Realgymnasium and of the Oberrealschule did not entitle the possessor to admission to the university.)

I. REPORT ON THE TEACHING OF MATHEMATICS.

Mathematics, it is stated, needs an adaptation to the modern problems of the schools. Especially should the instruction seek to strengthen the ability to grasp space concepts, and to train the pupils in the use of the notion of functionality. Some of the subject matter in the present curriculum which is not essential should be omitted (all artificial and pedantic proofs and operations, divisions of complicated polynomials and so on).

The abstract may in part be replaced by the concrete.

The teacher should have freedom in choosing the method of presenting a subject, apportioning the work, and so on.

"The goal of the instruction in mathematics during the last three years appears to be three fold:

"A methodical survey of the logical order and connection of the mathematics studied in the school; an ability to grasp mathematical

*Reformvorschläge für den Mathematischen und Naturwissenschaflichten Unterricht. Von A. Gutzmer, 1905. Teubner 25 cents. Postage 5 cents.

concepts and to apply them in individual problems; finally and above all the discernment of the value of mathematics for an exact knowledge of nature, and for modern culture in general."

The mathematical curriculum which is proposed introduces many minor changes. Graphs, which are not mentioned in the old curriculum are introduced in the fifth year. In arithmetic, problems from the daily life are to be be used. In algebra the use of many problems from geometry and physics, especially from mechanics, is recommended. Possibly the elementary notions of the calculus may be introduced to a greater extent than at present.

(There is a review of this part of the report in the *Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht.* 2 Heft, 1906.)

II. Report on the Teaching of Physics.

1. Problems of physics teaching.

The teaching should furnish not only a body of knowledge for use in life, and prepare the pupils to give a true description of what they have observed, but should also give them an insight into the laws of natural phenomena.

2. Number and distribution of hours of instruction.

At present the number of hours of instruction in physics in the Gymnasien is two hours per week in the three upper classes, and in the next two lower classes two hours per week for one and one half years including some instruction in chemistry. The commission recommends three hours per week in the upper three classes. In the Oberrealschulen and Realgymnasien the commission recommends three hours per week in the five upper classes, an increase of one hour per week during two years.

3. Method of instruction.

"Physics has been handled largely as a mathematical science. The instruction has lain and yet lies in the hands of those who are in the first place mathematicians. Until recently in the examinations for teachers of physics, much more weight has been laid on a knowledge of mathematical physics than on a knowledge of the empirical side of physics."

Hence, "Fundamental proposition I. In the instruction physics is to be handled not as a mathematical science but as a natural science." "An injury not less great than that arising from a one-sided mathematical presentation of physics comes from an opposite cause, namely, when the experimental side is emphasized exclusively, and through the presentation of numerous and brilliant experiments a clear grasp and thoughtful elaboration of the subject is lost."

Hence, as fundamental proposition II. "Physics as a material for instruction is so to be handled that it may serve as a model for all instruction in the domain of empirical knowledge."

"Finally it is not sufficient that the pupils should see from a distance the experiments performed on the teacher's table in the class room. 'Man lernt selbst beim einfachsten Experiment erst umsichtig, logisch

und kritisch beobachten und handein, wenn man es selbst ausführen muss.' Hence the pupil should have the possibility of close contact with objects through experiments."

Hence, "Fundamental proposition III. For the training of pupils in physics, systematically arranged exercises in observing and experimenting are necessary."

4. The curriculum in general.

5. A proposed curriculum.

6. Comments on the curriculum.

7. Practical exercises for the pupils.

In some Realanstalten such exercises have been arranged for hours outside of the regular instruction hours; in some cases the pupils were required to attend, but in general all the pupils took part in the exercises even though attendance was not compulsory.

III. Report on the Teaching of Chemistry Together with Mineralogy, and Zoology Together with Anthropology, Botany, and Geology.

The commission recommends that at least two hours per week should be given to chemistry and mineralogy in the three upper classes; and that two hours per week should be given to the other sciences in all nine classes. This part of the report covers sixteen pages.

It is to be hoped that this report of the commission will be widely read in America. It shows that the movement for reform in the teaching of mathematics and science in Germany has much in common with the similar movement in the United States, and is a valuable contribution to the reform literature of the present day.

PHYSICS CLUB OF NEW YORK.

The thirty-seventh regular meeting of the Physics Club of New York was held in connection with the annual dinner of the Club on June 2 at the Hotel Albert, with President Albert C. Arey presiding. After the dinner, which was attended by thirty-two club members and invited guests, much routine business was disposed of. An invitation was received from the Physics and Astronomy section of the New York Academy of Sciences to hold a joint meeting with them at some time during the coming year. This invitation was accepted and the President was authorized to arrange for the meeting. The notice of publishers of School Science and Mathematics that the price of club subscriptions would have to be raised to $1.25 per year was considered and the Treasurer was instructed to continue the club subscription at that rate.

The principal address of the evening was given by Prof. C. R. Mann of the University of Chicago on "The aims, tendencies, and effects of present physics teaching." A full report of this address, which was extremely interesting and instructive, we hope to publish in School Science and Mathematics. The position taken by Prof. Mann was that the present method of physics teaching is, in general, too abstract,

too mathematical, too devoid of human interest; that the results are lacking in disciplinary and cultural value for these reasons. Dr. A. C. Hale, Prof. J. F. Woodhull, Dr. Wm. Felter, principal of the Girls' High School in Brooklyn, also spoke, supporting in the main the criticisms of Prof. Mann. Mr. Currie said that as a Harvard man he advocated the Harvard method, which was under criticism. Prof. Mann said that a debt of gratitude was due to Harvard for the great interest and help which that university had contributed to Physics Teaching in this country but that in his opinion the Harvard course should be modified for the majority of high school pupils. The annual reports of the Secretary and of the Treasurer were read and the following officers were elected for the ensuing year: President, R. H. Cornish; Vice-President, J. F. Woodhull; Secretary, F. R. Strayer; Treasurer, R. H. Hopkins. R. H. C.

THE MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS AND SCIENCE.

The Missouri Society of Teachers of Mathematics met in Columbia on May 5. At a previous meeting arrangements had been partially made for the enlargement of the society so as to include teachers of science. In accordance with these arrangements two divisional meetings were held, a mathematics division and a science division. At the business meeting amendments to the constitution were formally adopted providing for the admission of teachers of science and for the holding of divisional meetings, and inserting the words "and Science" in the name of the society. All teachers of science in Missouri are cordially invited to join with us. SCHOOL SCIENCE AND MATHEMATICS is the official organ of the society and is sent free to all members. The next regular meeting of the society will be held in December at Moberly in connection with the State Teachers' Association.

The following program was carried out:

Mathematics Division.

Paper: "The Mathematics of Insurance," O. D. Kellogg, University of Missouri, Columbia.

Paper: "On the Foundations of Method in the Teaching of Mathematics," John W. Withers, Teachers College, St. Louis.

Paper: "Trigonometry," Geo. R. Dean, School of Mines, Rolla.

Paper: "Euclidean vs. Modern Geometry," E. R. Hedrick, University of Missouri, Columbia.

Paper: "On the Importance of Order as an Element of Mathematical Instruction," Alexander S. Chessin, Washington University, St. Louis.

Paper: "Models for Teaching Elementary Geometry," H. Clay Harvey, State Normal, Kirksville.

Round Table Discussion: The Teaching of Algebra.

"The Point of View of the High School," Wm. A. Luby Central High School, Kansas City; J. Allison Gaines, McKinley High School, St. Louis.

"The Point of View of the College," R. R. Fleet, William Jewell College, Liberty; Oliver E. Glenn, Drury College, Springfield.

"The Point of View of the University," A. S. Chessin, Washington University, St. Louis; L. D. Ames, University of Missouri, Columbia.

"The Point of View of the Editor," R. L. Short, Chicago, Ill.; C. M. Turton, Chicago, Ill.

"The Point of View of the Physics Teacher," J. S. Stokes, State Normal School, Kirksville; S. A. Douglass, Central High School, St. Louis.

Science Division.

Paper: "The Electronic Theory of Electricity and Matter," O. M. Stewart, University of Missouri, Columbia.

Paper: "Some Suggestions for Instruction in Physics," William M. Butler, Yeatman High School, St. Louis.

Paper: "Education through Nature Study," W. T. Utterback, High School, St. Joseph.

Paper: "Burbank's Work with Plants," R. W. Clothier, State Normal School, Cape Girardeau.

Paper: "The Space Occupied by Atoms," H. Schlundt, University of Missouri.

The following are abstracts of part of the papers:

Dr. Kellogg mentioned the nature of insurance as an application of mathematics, and gave a brief resumé of the method of calculating pure premiums. He made it clear that a brief elementary treatment of insurance can be presented to a class which has had a fairly good course in algebra. In view of the difficulty of finding really modern practical applications of algebra, this subject seems worthy of consideration.

Mr. Withers stated two problems connected with the teaching of elementary and secondary mathematics, and emphasized the necessity of placing their solution, if possible, upon a basis of scientifically determined fact and theory. He stated that in his judgment such a society as the one he was addressing could undertake no work that promised more for the improvement of present-day teaching of elementary mathematics than that of devising ways and means of working out these problems in a scientific and unprejudiced fashion. The first problem relates to the subject matter of mathematics and the educational value of the subject. What is the intrinsic, matter-of-fact value of mathematics as an instrument of education? Or, to put it differently—"In what sense and to what extent is the power gained through the proper study of mathematics available for the mastery of other subjects and of the actual problems of real life?" The speaker stated that the educational value of mathematics might be, and is, often overrated by devotees of the subject, and suggested ways of solving the problem in an unbiased manner.

The second problem deals with the question of method, and was stated as follows: "Having determined as nearly as we can what the educational value of mathematics is, or rather ought to be, we next ask how can this value be most fully realized through instruction?" Here the speaker emphasized the need of taking account of certain interesting principles of mental development that have been quite fully determined by current psychology.

Mr. Dean's paper is in abstract as follows: The improvements in the methods of teaching trigonometry have not kept pace with those in other branches of mathematics. The opening chapter of the current text-books, except in the case of two or three of the more recent ones, are filled with a miscellaneous collection of tricks with ratios, functions and formulæ. The student is kept in the dark as to the real object of the work until about half through the course. It would seem that all of the errors which have been eliminated from our courses in arithmetic, algebra, and geometry had been accumulated in the opening pages of our books on trigonometry. The writer presented a method of opening up the subject which has worked well in his own experience. It consists in defining one function only at the outset, viz., the sine of an acute angle, and working as many exercises and problems as possible with this one implement; introducing the other functions where necessary to abridge calculations and to derive more convenient formulæ.

Dr. Hedrick called attention to the surprising conservatism in the teaching of elementary geometry, and pointed out that probably no other topic of human thought has undergone so little revision in the two thousand years since Euclid wrote his famous treatise. Moreover, in this lapse of time many beautiful, simple, useful facts in geometry have been discovered. In fact the old text of Euclid is but a small fraction of our present geometrical knowledge.

It was suggested that very careful conservative experiments might be made toward introducing some simple facts in geometry to replace some useless material in the old Euclid texts. In particular, extreme stress on axiomatic development of geometry was deprecated, in view of the modern discoveries which make such discussion too philosophical and too profound for children. The individual proofs, the individual logical processes should remain and should be emphasized. Some theorems may be replaced, for example, such theorems as the inscription of a pentagon, and again the so-called *incommensurable* cases.

On the other hand some work is readily put in which is now omitted: graphical pictures, the equations of simple curves, in particular the circle equation. The fact of the introduction of these same concepts in algebra in the majority of schools and texts makes such a change easier and more desirable, and will lead to more easy passage between the two subjects. Other changes may be made slowly if these are found to succeed.

Extreme caution was urged in any changes in any subject, and especial warning was given *not to overdo* the now popular and successful work on graphs in algebra. Even a good innovation when carried to an extreme will mean *reaction*.

Professor Chessin pointed out that "order" forms an important feature of every phase of education. He urged that particular attention be given to it in the teaching of mathematics by instilling in the pupils a habit of thinking clearly and logically, and requiring them to observe more order and neatness in their presentation, both in oral arguments and written work.

Mr. Harvey presented in detail the use which can be made of models in the teaching of geometry. He said that clear definitions of the appro-

priate solid should be given before the model is used. Give the demonstrations with the model and follow it with the analytical demonstration.

The ideas presented in the round table discussion can perhaps be most economically summarized in a composite report.

The following subjects were recommended for omission from courses in elementary algebra: Examples in the fundamental operations involving very complex literal exponents; factoring by the remainder theorem; highest common factor by successive division; cube root; indeterminate equations; the properties of quadratic surds; imaginaries; the proof of the binomial theorem beyond the third power; variables and their limits; properties of infinite series; undetermined coefficients.

In this connection Professor Chessin pointed out that American textbooks inherited from their English prototypes a mass of superfluous, artificially inflated subject matter having no value from either an educational or utilitarian standpoint. In this respect they greatly differ from the text-books used on the continent of Europe, notably in France, the country which has produced the greatest mathematicians and the best works on mathematics.

More intensive and less extensive was the watchword. The best preparation for life should be accepted as preparation for college entrance.

It was suggested that the following subjects should receive greater emphasis: the fundamental processes; the use of practical formulæ and the solution of equations for any letter which may occur in it and the substitution of values of the various letters; equations involving fractions and decimals; the expression of results in decimal form; quadratic equations; more really practical problems; an occasional bit of history; a glimpse of some elegant results to follow.

Mr. Stokes called attention to the fact that quantitative experiments in physics usually consist in obtaining a set of corresponding values of two mutually dependent variables. The experimenter applies two methods to these sets of values to determine their relation: (1) the analytical, involving the equation variation and proportion; (2) the graphical method. Students seldom use these methods with sufficient skill, and this often leads to the idea that physics is a "hard" study. Mr. Stokes urged that teachers of mathematics should become more familiar with the practical application of mathematics in the arts and sciences, especially in physics and mechanics.

Students are generally weak in the subject of variation, in the use and interpretation of the *factor of proportionality*, and in passing from a variation to a proportion. The method of testing the justness of a proportion, viz., the product of the extremes equal to the product of the means, is not the best method. When the numbers are large this method may show large differences in the products when in reality the ratios are as nearly equal as the permissible error would require.

Mr. Stokes stated that the instruction in *graphics now being given* in algebra makes the practical application somewhat easier, but that the student still leans heavily on the physics teacher for support in his graphical work.

In regard to the use of the graph in elementary algebra it was generally recognized that it had come to stay, and on the whole there seemed to be pretty general satisfaction with what has already been done in that line. A few notes of warning were sounded as to the danger of overdoing this work in a mechanical way and making it an end in itself. It was suggested that the graph may become an abstract, meaningless symbol as well as the equation, and that to avoid this extreme we should constantly strive to keep a vital relation between the two symbols, the equation and the graph on the one hand, and the practical concrete problems on the other. Geometric images should be used to clarify the subject, not to usurp it. The physics teachers especially urged that students be led to greater appreciation of the use of the graph and greater facility in its use.

PAPER—SOME PRACTICAL SUGGESTIONS FOR INSTRUCTION IN PHYSICS.

Abstract—By W. M. Butler, Yeatman High School, St. Louis.

I. For the better understanding of the principle of Archimedes, the following method has proven helpful. A brass cylinder about 2cm. diameter and 6cm. long, with squared ends, is carefully weighed in air and in water, and the loss of weight determined. Then the length and diameter are determined with a vernier caliper reading to hundredths of a mm. The volume is computed by the formula $V = .7854\, d^2 \times h$. When the student sees that the number expressing the loss of weight is also the number expressing the volume, he at once acquires a clearer idea of the law than he can possibly get from the usual plan of measurement, in which the volume is only inferred, but not actually ascertained.

II. In dealing with capillary tubes, the diameter may be readily found with sufficient accuracy for class work by cutting a tapering plug of soft wood, pushing the plug into the tube till a shoulder is formed, and then measuring the diameter at the shoulder. This is simpler than the weight of mercury method often employed, and prevents the pupil's losing sight of the facts of capillarity, while making the complex computations entailed in the mercury method.

III. To determine the ratio of the diameter to the circumference of a circle, it will be found that excellent results may be had by using a circular brass disk, supporting the disk on a ¼″ wooden block, and wrapping a paper tape about the disk tightly so that the ends overlap. If a pin be pricked through the tape and the distance from pinhole to pinhole is then determined, the ratio may be readily determined to within ½ per cent, an error smaller than that considered permissible in most high school laboratory work.

IV. To demonstrate the law of intensity of radiation, which usually causes so much trouble to beginners, the following arrangement has proved helpful: An arc lamp is used as a source of light and heat. 12″ away from the arc is set up a screen of black cardboard with an opening 1″ square cut at its center. If a white screen is now put 24″ from the lamp, behind the opening, it will be found that the spot of light is now 2″ × 2″, or 4 sq. in. At 36″ from the lamp, the spot will

occupy 9 sq. in. or 3″ ×3″. If a lamp cannot be had, put for the lamp a piece of cardboard with a hole about ⅛″ diameter, through which the student may look at the opening in the screen and the white cardboard beyond. He will see only so much of the screen as indicated above, and if his eye is replaced by a lamp, evidently only so much of the screen as he has seen will be illuminated.

V. To make clear the cooling due to evaporation, a flat-bottom flask of about 200cc. capacity is fitted with a perforated rubber stopper in which is inserted a slender glass tube, the whole thus serving as an air thermometer, when inverted and the open end dipped into colored water. If a drop of water is now put on the flat bottom, the column of water shows little cooling by evaporation; if alcohol is used, the cooling is more marked; if ether be used, the cooling is at once greatly increased.

Mr. Utterback traced the important part that man's attitude towards nature has played in the development of civilization. He emphasized the large part that a knowledge of nature serves in the development of our esthetic natures, and in the development of the moral elements of fidelity to truth and intellectual integrity, and independence of thought and judgment. Out of the laboratory and sense-perception idea grows up the institution of manual training.

Some of the papers read were of such a nature that they cannot be satisfactorily summarized in a brief abstract.

L. D. Ames, Secretary.

CONDITION IN WHICH COAL IS CHARGED INTO THE OVENS.

In the forthcoming report of Mr. Edward W. Parker, statistician of the United States Geological Survey, on the production of coke in 1905 will be found a statement of the condition to which the coal was charged into the ovens in the several States and Territories during the last two years, and a resumé of the corresponding statistics for the last fourteen years during which these statistics have been compiled.

About two-thirds of the entire amount of coal used in coke-making is run of mine coal, most of which is charged into the ovens without being washed. It has been found, however, that the coking process is in many cases facilitated and a better quality of coke obtained if the coal is crushed before it is charged into the ovens, and a large amount of the run of mine coal is crushed, or disintegrated, before coking, whether it is washed or not. Little, if any, large-sized coal is coked in by-product ovens. During 1905 14,559,369 short tons, or 29.4 per cent of the total quantity of coal used in coke making, was slack, and of this slack coal 6,363,143 short tons, or 43.7 per cent, was washed before it was coked. Of the run-of-mine coal used in coke-making less than ten per cent (3,187,994 tons out of a total of 34,971,308 tons in 1905) was washed before it was coked.—*United States Geological Survey.*

MATHEMATICAL NOTES.

The printed minutes of the last meeting of the Association of Teachers in Mathematics in the state of Washington contains the following papers:

1. Relation of Mathematics to Applied Science,
O. L. Waller, State College of Washington.
2. Present Day Defects in the Teaching of Secondary Mathematics,
J. C. Keiths, Seattle High School.
3. Some Definitions Considered with Reference to the Derivation of Operations from Them, W. A. Bratton, Whitman College.
4. A Preliminary Report on a Proposed Text of High School Mathematics, Robert E. Moritz, the University of Washington.
5. Mathematics in the High School—Its Subject Matter and Methods, John L. Dunn, Spokane High School.

Those interested may write Secretary Zella E. Bisbee, High School, North Yakima, Wash.

A 20-page pamphlet reporting the proceedings of the Department of Mathematics of the High School Teachers' Association of New York City contains these papers:

I. THE COURSE IN MATHEMATICS DURING THE SECOND AND THIRD YEARS OF THE HIGH SCHOOL.
   1. The Aim of Mathematical Teaching in the Secondary School, John H. Denbigh, Principal Morris High School.
   2. Defects of the Present Course,
   Albert E. King, Erasmus Hall High School.
   3. The Present Syllabus, Properly Interpreted, Provides for the Continuity of Algebra, and is Sufficiently Effective,
   A. Latham Baker, Manual Training High School, Brooklyn.

II. THE THEORY OF LIMITS.
   1. The Theory of Limits,
   Thomas S. Fiske, Columbia University.
   2. Limits of Geometric Forms,
   A. Latham Baker, Manual Training High School, Brooklyn.
   (*v.* SCHOOL SCIENCE AND MATHEMATICS.)
   3. The Theory of Limits in Geometry,
   Walter Barnwell, DeWitt Clinton High School.
   Review of Recent Literature on the Theory of Limits,
   Thomas F. Kane, Curtis High School.

III. REPORTS ADOPTED BY THE DEPARTMENT
   1. The Committee on the Theory of Limits,
   2. The Committee on the Organization of a Permanent Council.

The secretary of the department for the year 1906-07 is Miss Jessie A. Beach, Girls' Technical High School.

LEADING ARTICLES IN SOME CURRENT MAGAZINES.

Popular Science Monthly for September has the following: "The Value of Science," M. H. Poincaré; "Discontinuous Variation in Pedigree-Cultures," Dr. D. T. MacDougal; "The Protection of the Alluvial Basin of the Mississippi," Robert Marshall Brown; "The Development of Mechanics," Dr. S. E. Slocum; "Diamonds and Carbons in Brazil," H. W. Furniss. In the October number: "The Earthquake Rift of 1906," illustrated, President David Starr Jordan; "The Scientific Aspects of Luther Burbank's Work," illustrated, Professor Vernon L. Kellogg.

Physical Review for August has "The Velocity and Ratio $e|m$ for the Primary and Secondary Rays of Radium," S. J. Allen; "Limitations of the Ballistic Method for Magnetic Induction," A. Hoyt Taylor; "The Trermo-electric Behavior of Silver in a Thermo-element of the First Class," W. D. Henderson; "Infra-red Absorption and Reflection Spectra," W. W. Coblentz; "The Contemporaneous Variations of the Nucleations and the Ionization of the Atmosphere of Providence," Lulu B. Joslin; "The Cadmium Standard Cell," George A. Hulett.

Review of Reviews for September: "Schools for the Out-of-School," H. V. Ross, with illustrations; "A Successful Factory School," with illustrations; "Tea Culture in the United States," Rodney H. True, with illustrations; "The Pike Exploration Centennial," Charles M. Harvey, with portraits and other illustrations; "Printing and Publishing: the Barometer Industry," W. S. Rossiter, with maps.

Scientific American Supplement of August 4: "The Ultramicroscope and its Chemical Applications," Dr. L. Michaelis; "Holes in the Heavens," J. E. Gore. For September 8 are articles on "The Colors of the Sky and the Solar Disk," Professor G. Sagnac; "The Internal Heat of the Earth and the Thickness of the Earth's Crust." For September 29: "The Nature and Origin of Volcanic Heat," Elihu Thompson; "The Structure of Metals," J. A. Ewing.

Scientific American of September 1 and 8 contain an illustrated article on "Sanitation of the City of Washington." September 8: "Searching for the Real Origin of Species." September 22 has an article on "How a Planet is Weighed," Frederick R. Honey, Trinity College.

Technical World for October contains "Bread-making by Machinery," Carol A. Stewart; "The Mississippi as a Mill-Stream," W. E. Pringle; "What About the Turbine?" Robert Cromie; "Colossal Asparagus Plantation," J. Mayne Baltimore. For September: "New Rival of Panama Canal," René Bache; "Gold in a Thousand Sand Pits," Waldon Fawcett; "Creating a New Harbor," N. A. Bowers; "World's Great Canals and Their Builders—3. The Kaiser Wilhelm Canal," William R. Stewart. For August: "Are the Elements Transmutable?" Robert A. Milliken, Ph.D., Assistant Professor of Physics in the University of Chicago.

Review of Reviews for August: "Brazil the Great Republic of the Tropics," G. M. L. Brown and Franklin Adams, with maps and other illustrations; "Free Alcohol in the Arts and as Fuel," Charles Baskerville.

Science of August 3: "To What Extent Should the University Investigator be Freed from Teaching?" President David Starr Jordan. September 14: "Botany in England." F. W. Oliver.

Farming for August contains the paper, "What the Farmer Can do with Concrete," Claude H. Miller.

The American Inventor for September: "Some Researches in Nerve Physics," Albert F. Shore; "Shifting Sands, How the Government is Fighting Sand with Grass," illustrated, W. S. Birge, M.D.; "Collins New Wireless Telephone System," with diagrams.

The American Naturalist for October: "Histogenesis of the Retina." Professor A. W. Weysse and W. S. Burgess: "Notes on Marine Copepoda of Rhode Island." L. W. Williams; "Lichens of Mount Monadnock, N. H.," R. H. Howe, Jr.

BOOK REVIEWS.

Familiar Wild Animals. By Silas A. Lottridge. P. 1151. Henry Holt & Co. 1906.

A very interesting narrative of six of the more common wild animals and the same number of birds. The book was written to help stimulate school children in the direct observation of outdoor life. It contains many photographs from nature by the author.

Eddy's Experimental Physiology and Anatomy for High Schools. By Walter Hollis Eddy, Chairman of the Department of Biology in the High School of Commerce, New York City. Cloth, 12mo, 112 pages with cuts and diagrams. Price, 60 cents. American Book Company, New York, Cincinnati, and Chicago.

This book has been prepared in an effort to call attention to the great field which physiology presents for laboratory study. The exercises given are such as to permit of their performance by the pupil with a minimum amount of direction from the teacher. The topics taken up cover both the requirements of the New York State Syllabus and those of the entrance examinations of Harvard College, and treat of such important subjects as the principles and organs of digestion, the blood and its circulation, the skeleton, muscles, and nerves, with studies of nutrients, foods, and bacteria. The book is interleaved with blank pages upon which the student may write his notes.

American Men of Science. A Biographical Dictionary. Edited by J. McKeen Cattell. The Science Press, New York. 1906. 4to. 7+364 pp.

The chief object of this work is to make American men of science acquainted with one another and with one another's work. In the field which it covers it is much more comprehensive than *Minera* or *Who's Who in America*, as it includes a tolerably complete list of sketches of those living in North America who have published any research in the natural and exact sciences, and in addition some entries of those who are held to have advanced science by teaching, by administration, or by the publication of text-books.

A valuable and novel feature is the star before the field of research in the case of about one thousand out of the four thousand biographical notes. This indicates that the subject of the sketch is to be regarded as one of the thousand leading American men of science. Those who are inclined to estimate the scientific standing of a man by the position which he occupies will be surprised at the relatively large number of names of younger men whose work is recognized in this way, while many who hold prominent positions are not classed among the leading scientists.

In view of the great difficulties in forming a correct estimate of the merits of the work of our contemporaries, the present undertaking appears a bold one, but the importance of accurate knowledge along this line seems to justify such ventures. All men of science and especially those who require the services of such men must feel keenly the difficulties encountered in the effort of judging the relative merits of the work of those who may be under consideration, and, as such

judgments are sometimes imperatively necessary, any reliable aid is a great desideratum. Moreover, there are few things which tend to contribute so much toward substantial progress as a general feeling that the opinions of experts in regard to individual achievements will speedily become common property. The present volume appears to be a decided step toward cultivating such a feeling.

It cannot be expected that the specialists who aided the author in picking out a thousand leading American scientists were successful in every particular and it is to be hoped that later editions will receive still more careful attention along this line. In reference to the younger men it is especially difficult to form reliable estimates, as the man who does one or two pieces of excellent work and then ceases to be productive is placed on the same basis as the one whose contributions increase in quality and quantity from year to year. Moreover, it frequently happens that work of the very highest merit is not justly appreciated even by specialists until several years after its publication while more superficial and temporarily popular work may receive undue credit. Yet these difficulties should only inspire caution. They should not lead men to prefer total ignorance to imperfect light on such important matters.

As far as possible each entry contains information on the following ten points: Name and mail address, department of investigation, place and date of birth, education and degrees, positions with dates, temporary and minor positions, honorary degrees and other scientific honors, membership in learned societies, chief subject of research, and whether the subject of the sketch is classed with "the thousand students of natural and exact sciences in the United States whose work is supposed to be the most important." As these facts are compiled with unusual care the volume will doubtless do much toward creating a more cordial feeling among scientists and a more just appreciation of their merits.

G. A. Miller,
University of Illinois.

BOOKS RECEIVED.

American Book Company, New York and Chicago.

Baker's Action Primer. By Thomas O. Baker, Ph.D., Principal of Public School No. 128, Brooklyn, New York. Cloth, 12mo, 112 pages, with illustrations. Price, 25 cents.

Fox's Indian Primer. By Florence C. Fox, Primary Critic, Milwaukee, Wis., Normal School; Primary Department, University School for Girls, Chicago. Cloth, 12mo, 120 pages, with illustrations. Price, 25 cents.

Melodic Music Series. By Frederic H. Ripley, Principal of the Longfellow School, Boston, and Thomas Tapper, Lecturer on Music at the Institute of Musical Art of the City of New York. First Reader. Cloth, 8vo, 128 pages. Price, 25 cents. Second Reader. Cloth, 8vo, 144 pages. Price, 30 cents. Third Reader. Cloth, 8vo, 198 pages. Price, 40 cents. Fourth Reader. Cloth, 8vo, 256 pages. Price, 50 cents.

Morey's Outlines of Ancient History. By William C. Morey, Professor of History and Political Science, University of Rochester. Half leather, 12mo, 550 pages. Price, $1.50.

Holder's Half Hours with Fishes, Reptiles, and Birds. By Charles Frederick Holder, author of "Elements of Zoology," "Stories of Animal Life," etc. Cloth, 12mo, 255 pages, with 244 illustrations. Price, 60 cents.

Brooks's Readers. By Stratton D. Brooks, Superintendent of Schools, Boston, Mass. First Year. Cloth, 12mo. 128 pages. Illustrated. Price, 25 cents. Second Year. Cloth, 12mo. 176 pages. Illustrated. Price, 35 cents, Third Year. Cloth, 12mo. 248 pages. Illustrated. Price, 40 cents. Fourth and Fifth Years. Cloth, 12mo. 360 pages. Illustrated. Price, 50 cents. Sixth, Seventh, and Eighth Years. Cloth, 12mo. 446 pages. Illustrated. Price, 60 cents.

GINN & COMPANY, NEW YORK, CHICAGO, AND BOSTON.

Text-Book in General Zoology. By Henry R. Linville, Head of the Department of Biology, DeWitt Clinton High School, New York City, and Henry E. Kelly, Director of the Department of Biology, Ethical Culture School, New York City. 462 pages. Illustrated. Price, $1.50; mailing price, $1.70.

HENRY HOLT & COMPANY, NEW YORK.

Forty Lessons in Physics. By Lynn B. McMullen, Instructor in Physics Shortridge High School, Indianapolis, Ind. Pages, viii + 452.

THE OPEN COURT PUBLISHING COMPANY, CHICAGO.

Space and Geometry. By Ernst Mach, Emeritus Professor in the University of Vienna. From the German by Thomas J. McCormick, Principal of the LaSalle-Peru High School, Illinois. 148 pages.

Essay on the Creative Imagination. By Th. Ribot, translated from the French by Albert H. N. Baron, fellow in Clark University. Pages xix+370.

LAIRD & LEE, CHICAGO.

Laird & Lee's Diary and Time Saver. 13 maps in four colors. Eighth annual edition. 1907. Price, 25 cents.

By the Eternal. A novel by Opie Read. Illustrated . Pp. 303. 1906. Price, $1.50.

PROPOSED AMENDMENT TO C. A. OF S. AND M. T.

That the office of secretary and treasurer be combined and that there be an assistant secretary-treasurer. That the secretary-treasurer give a bond for $1,000, the expense of said bond being paid by the association, said bond to be approved by the executive committee. The term of office of the secretary-treasurer to be three years. The assistant secretary-treasurer to be elected annually. All bills must be approved by the executive committee and signed by the president and vice-president before being paid.

That there be one vice-president to be elected annually.

Chairmen of local centers shall be members of the executive committee.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The sixth annual meeting will be held in the buildings of the University of Chicago on Friday and Saturday, November 30 and December 1, 1906. At the general session on Friday morning addresses will be given by Professor William Davis of Harvard University and Professor Lyman C. Newell of Boston University. On Friday evening from 5:30 to 6:15 there will be an informal reception in the Reynolds Club. Following this reception there will be a dinner in the men's commons at which time will be given an after dinner address by Professor J. F. Woodhull of Teachers' College, Columbia University.

The section programs will contain the names of Professors H. L. Coar (Mathematics), Urbana, Ill.; H. E. Cobb (Mathematics), Chicago; E. B. Skinner (Mathematics), Madison, Wis.; John E. Cameron (Biology), Kansas City, Mo.; Frank Smith (Biology), Urbana, Ill.; Franklin T. Jones (Physics), Cleveland, O.; C. R. Mann (Physics), Chicago; Alexander Smith (Chemistry), Chicago; W. J. Sutherland (Earth Science), Macomb, Ill.; J. Paul Goode (Earth Science), Chicago, as well as other teachers in colleges and secondary schools. After Professor Woodhull's address on Friday evening and after the general business session on Saturday morning the physics and chemistry sections will meet with the American Physical Society, which meets at the University of Chicago on the above dates. Other section meetings will be held on Friday afternoon and Saturday morning.

The full program of the meeting will be mailed about October 15. Members of the association who wish copies of the program sent to persons who are not members should send addresses to the president or secretary.

Otis W. Caldwell, President,
Charleston, Ill.
C. M. Turton, Secretary,
440 Kenwood Terrace, Chicago.

The Directory of Science and Mathematics Association which has been printed on the first three pages of the advertising section will hereafter be printed only in the October, February and June issues. Use now the directory printed in the October number.

ERRATUM.

On pages 665 and 666 "Tides" wherever found should read "Sides."